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In this issue

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Directory of Professional Services—pp. *57-62 P&R*

AWWA ANNUAL CONFERENCE

Chicago, Ill. June 12-17, 1955

All reservations are being cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1955 Conference except as they are requested on the standard form, through the AWWA.

Coming Meetings

AWWA SECTIONS

Nov. 3–5—Virginia Section at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, 213 Carlton Terrace Bldg., Roanoke 11, Va.

Nov. 4–6—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan, Inc., Box 178, Newark 1, N.J.

Nov. 7–10—Florida Section at Soreno Hotel, St. Petersburg. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica-Burnett Chemical Co., Box 2328, Jacksonville, Fla.

Nov. 8–9—West Virginia Section at Prichard Hotel, Huntington. Secretary, H. K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston 5, W.Va.

Nov. 8–10—North Carolina Section at George Vanderbilt Hotel, Asheville. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh, N.C.

Nov. 9–10—Rocky Mountain Section at Broadmoor Hotel, Colorado Springs, Colo. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

(*Continued on page 10*)

Coming Meetings

(*Continued from page 6*)

Dec. 2–4—Cuban Section at Sociedad Cubana de Ingenieros, Havana. Secretary, Laurence H. Daniel, Pres., Laurence H. Daniel, Inc., Baratillo 9, Havana, Cuba.

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Feb. 9–11—Indiana Section at Lincoln Hotel, Indianapolis. Secretary, Robert J. Becker, Asst. Supt. of Purif., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6.

Mar. 21–23—Southeastern Section at DeSoto Hotel, Savannah, Ga. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Public Health, 245 State Office Bldg., Atlanta 3, Ga.

Apr. 13–15—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civ. Eng., Univ. of Nebraska, Lincoln.

Apr. 13–15—Kansas Section at Baker Hotel, Hutchison. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud St., Salina.

Apr. 14–16—Arizona Section at San Marcos Hotel, Chandler. Secretary, Quentin M. Mees, Arizona Sewage & Water Works Assn., 721 N. Olsen Ave., Tucson.

Apr. 18–20—Canadian Section at Chateau Frontenac, Quebec. Secretary, A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 8, Ont.

Apr. 20–22—New York Section at Hotel Statler, Buffalo. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand St., White Plains.

Apr. 29–30—Montana Section at Finlen Hotel, Butte. Secretary, A. W. Clarkson, Acting Chief, Water Section, Div. of Environmental Sanitation, State Board of Health, Helena.

May 4–6—Pennsylvania Section at Webster Hall, Pittsburgh. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

May 19–21—Pacific Northwest Section at Hotel Chinook, Yakima, Wash. Secretary, Fred D. Jones, Dist. Supervisor, Rm. 305 City Hall, Spokane, Washington.

OTHER ORGANIZATIONS

Nov. 17–19—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 18–19—Western Regional Conference of National Assn. of Corrosion Engrs., at Los Angeles, Calif.

Nov. 19—Pennsylvania Clean Streams Conference at Penn-Harris Hotel, Harrisburg.

Nov. 28–Dec. 3—American Society of Mechanical Engineers, at Statler Hotel, New York.

Nov. 29—Water Conservation Conference (during meeting of American Society of Refrigerating Engrs.), at Benjamin Franklin Hotel, Philadelphia.

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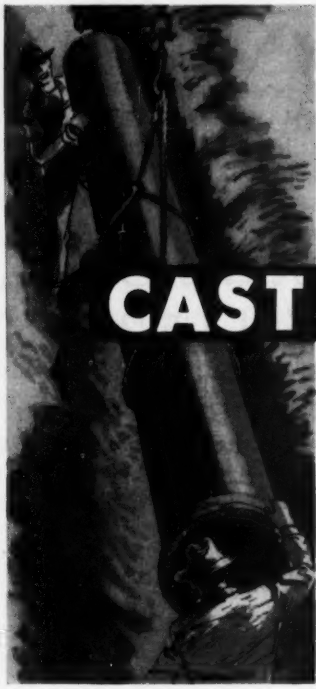
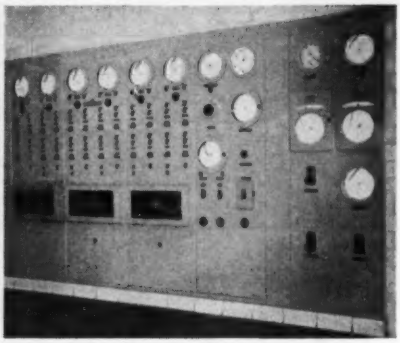
Mar. 7–11—National Assn. of Corrosion Engrs., at Palmer House, Chicago.

Mar. 28–Apr. 1—Western Metals Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

Jul. 18–22—International Water Supply Assn. Congress, London.



Aldrich Purification Units and Filters at Alexandria plant of American Water Works Service Company.



Central control panel from which effluent and backwash rates are remotely controlled by Builders Auto-Central Control.

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The same type of automatic time-sequence operation which has won such wide acceptance for automatic home washing machines now comes to the modern water works. Here is one of the first installations of Builders Auto-Central (automatic-centralized) filter Control, proven by over three years of successful operation at the Alexandria Water Company in Alexandria, Virginia.

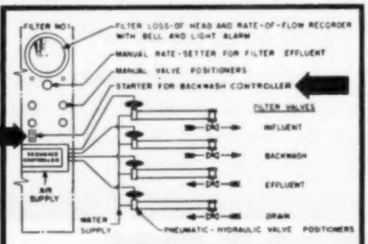

Diagram of control panel for Filter No 1.
Operation may be manual or automatic as desired.

Auto-Central Filter Control is another example of Builders' pioneering in the water works field. For complete details on this or other types of Builders Water Works Equipment, write Builders-Providence, Inc. (Division of B-I-F Industries, Inc.), 365 Harris Ave., Providence 1, R. I.

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AMERICAN WATER WORKS ASSOCIATION

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Selection of Valves for Water Works Service

By Leslie Paul

A paper presented on May 27, 1954, at the Annual Conference, Seattle, Wash., by Leslie Paul, Supervising Mech. & Elec. Engr., East Bay Munic. Utility Dist., Oakland, Calif.

IN water works systems on the banks of large rivers or the shores of lakes where the terrain is flat and water can be distributed through one large, well developed network in one pressure zone, the application of valves and other mechanical devices has evolved into a fairly standardized and comparatively simple pattern. The East Bay Municipal Utility Dist. is not so fortunate, because its 208-sq mile service area, in which it furnishes 114 mgd to 1,000,000 people, varies in elevation from sea level to 1,552 ft. The bulk of the water must be transmitted from the main catchment area in 65-in. and 68-in. pipelines for a distance of approximately 95 miles. The service area is bisected by a main ridge of hills, with branch spurs and steep canyons projecting into the sides, and several other hill systems are also present. With such terrain to serve, district personnel have had to become familiar with most available water-controlling devices.

Water works valves can be classified in several ways. One method would be to differentiate between isolating and operating valves. An isolating valve is a device for blocking off a section of pipe in a grid system or protecting operating valves or pumping units, so that inspection or maintenance can be carried out without removing them from the line. An operating valve is one that is used frequently for starting, stopping, or regulating flow or for regulating pressure.

In this paper, valves are divided into seven principal categories: sluice gate, needle, check, butterfly, plug, globe, and gate. There are other types of valves—such as shear gates, mud valves, tide or flap valves, and hydrant valves—which are designed for special applications where selection of type is not a matter of judgment.

Sluice Gates

Sluice gates are used principally on inlet or outlet pipes entering reservoirs, on the side openings of reservoir control towers, and on flume and canal systems where a throttling or shutoff device im-

mersed in the water must take pressure on one side of the leaf only, so that pressure tends to seat the gate.

Sluice gates are obtainable with both rising and nonrising stems, but the use of the latter should be discouraged. The threaded section of a rising stem, being out of the water, serves as a position indicator and can be made of steel. It can be lubricated and no torsional stresses are transmitted to the disc and guides. In the nonrising-stem type, the working parts are immersed in water and cannot be lubricated. The operating nut, rigidly fastened to the disc, and the operating stem must be made of bronze. In operating the gate, the torsional stresses applied to the stem are transferred to the disc and guides. If a sluice gate of this pattern is operated infrequently, the threads of the stem and nut tend to freeze together and the extra torsion necessary to loosen them may break the stem at its point of greatest weakness, the inner end of the threaded section.

Sluice gates manufactured by old, established firms are practical, quality products, standardized to cover a wide range of sizes and pressures. The structural features are well designed and proportioned.

A sluice gate assembly is no stronger than its weakest part. Very often it is the bolting that shows up badly, especially where conditions for setting up galvanic couples are favorable. These may exist where a sluice gate frame is bolted directly to a concrete wall, especially if the bolts are in contact with reinforcing steel. In that event, the steel part imbedded in the concrete will tend to destroy electrolytically the part not so imbedded, the nut deteriorating first. Bolts in contact with bronze parts should be of silicon bronze or equal, to prevent such corrosion. The bolting should be as durable as the castings, and under no circumstances should a steel nut be used on a bronze bolt, or a brass or bronze nut on a steel bolt.

Various kinds of copper alloys on the market are being sold as bronzes. Some of these are not bronzes but different degrees of high-zinc brasses, although the insidious fact is that they all look alike. The word "bronze" should not be used indiscriminately to cover all metals with a yellow color. It is important that the composition of bronzes be described and specified within given limits, in accordance with ASTM or other recognized standards rather than by a manufacturer's trade name. The manufacturer should be willing and able to comply with ASTM or similar requirements.

Valve manufacturers favor certain so-called bronzes for reasons of machinability, cost, and tradition. Many are not bronzes but high-strength, leaded, yellow brasses with high zinc content and thus are susceptible to dezincification in some waters. Hence, such alloys should be avoided in writing valve specifications if better ones are available

When sluice gates are infrequently operated, and especially when they are not readily accessible, the gate and guide tongues and grooves should be covered or lined with low-zinc bronze, stainless steel, or Monel metal. All sliding, rubbing, or wedging surfaces should be bronze to bronze, stainless steel to stainless steel, or Monel to Monel.

The safety factor is important in selecting a sluice gate frame for use in waters that cause graphitization, especially if the commonly employed ASTM A126, Class B, cast iron is to be the frame material. A safety factor of five should be an absolute minimum for cast-iron parts subjected to predictable stresses. Sluice gate frames can be

flexed very easily, so that bolting and wedging action may produce higher stresses than anticipated if the original installation results in improper frame warping. For guide sections and bolting subjected to wedging action, the safety factor should be much higher, probably not less than fifteen.

The most satisfactory sluice gate installations are those which are flanged and bolted to a flanged wall thimble embedded in the concrete structure. This arrangement makes installation easy, eliminates warping of the frame, and permits removal of the gate without disturbance to the masonry. Gates that are bolted to the masonry are easily warped, as masonry surfaces can never be built true and flat like a machined metal surface, and water leakage between the frame and the masonry can erode away enough concrete to make the installation ineffective as a water stop.

Needle Valves

Needle valves (Fig. 1 and 2), in the smaller sizes, are used principally for fine regulation of flow through pilot control mechanisms, because a large movement of the hand wheel results in only a slight movement of the needle with relation to the valve seat. These small, hand-operated valves resemble the globe type, except that, instead of a disc, a streamlined or tapered plug fits into a ground seat. The fluid flows around the plug and through the seat.

In the larger sizes, needle valves have a variety of applications. An important one is the throttling and control of free discharge from reservoirs and pipelines. Medium-size valves are operated mechanically in various ways, but the large sizes are usually controlled hydraulically by the internal-differential method. Because the fluid must flow longitudinally around the outside of the plug, the hydraulic-power elements and the working parts are buried within the body of the valve. A disadvantage of this arrangement is the comparatively high weight of the valve for any given size. Means of getting around this difficulty have received much study, especially by the US Bureau of Reclamation and some of the big power companies that use these valves in very large sizes. The Bureau of Reclamation has improved on the internal-differential valve with what it calls a tube valve, but needle valve design seems to be in a continuing state of modification. (The East Bay system has 22 needle valves, ranging in size from 6 in. to 72 in., all purchased from the same manufacturer.)

The cylinder gate represents an interesting attempt to overcome one of the disadvantages of the needle valve by making the working parts accessible on the outside of the valve. The plug or needle remains stationary, with the point upstream, and a cylinder is drawn back in the upstream direction, which uncovers four ports, causing wide-angle discharge. Where wide-angle discharge is undesirable, a hood can be built to confine the normal expansion of the jet. This valve is capable of discharging a greater quantity of water than conventional needle valves of the same nominal diameter.

The needle valve is sometimes used to regulate flow or pressure in a pipeline, but, when repairs are necessary, the valve body must be removed from the line. (Two of the East Bay needle valves are 6-in. pressure regulators.)

The sleeve valve is another attempt to avoid some of the difficulties of the needle type installed in pipelines. For maintenance or repair, the body and working parts of the sleeve valve can be

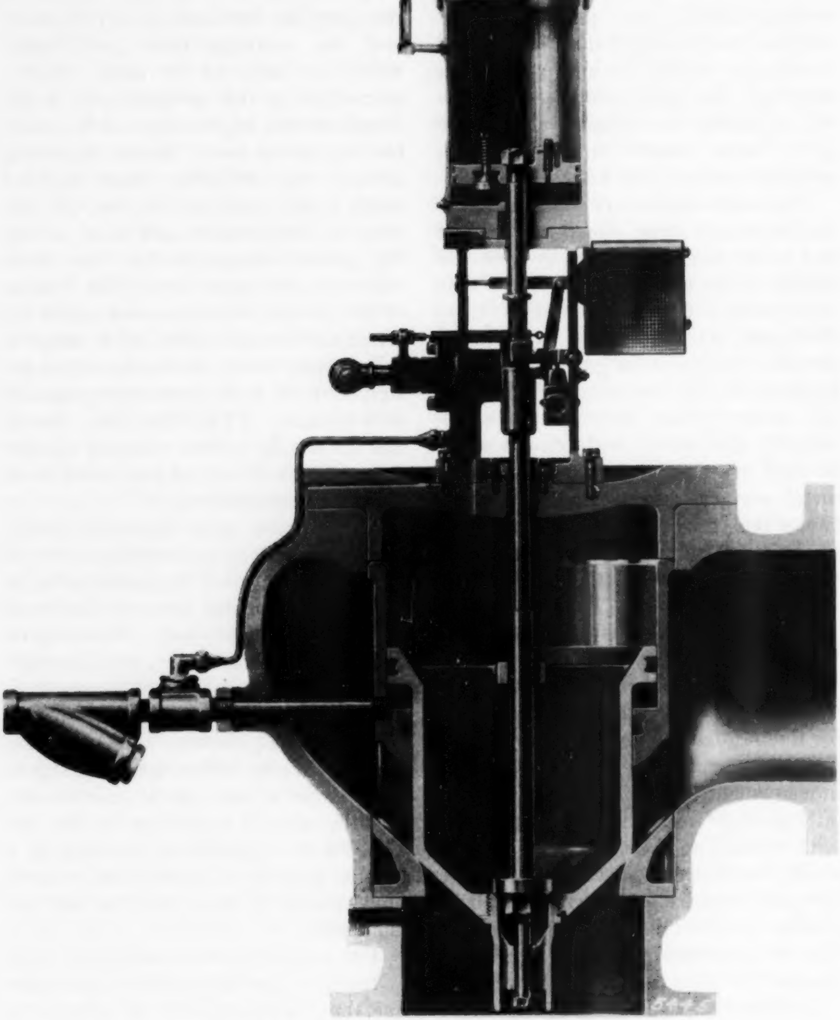

Fig. 1. Needle Type Surge Suppressor

The needle valve has a variety of applications.

lifted out of the line without breaking the flange connections to it.

Needle valves may be used as check valves on pump discharges where controlled speed of closing is essential or where the flow must be throttled to a given rate. (East Bay employs one 18-in. and three 24-in. conventional needle valves and three 30-in. sleeve valves for this purpose.)

Needle nozzles are used for controlling the stream jet against the buckets

in impulse type water turbines. They are also used for directing the stream in hydraulic mining.

Check Valves

In spite of claims by manufacturers and their sales representatives, there is no such thing as a check valve that "eliminates water hammer." The effect of water hammer may be mitigated by the speed of operation of a certain type of valve under a given set of conditions, but no valve ever nullifies it entirely. Furthermore, a check valve that works well under the conditions imposed by one installation may not work well in another installation. When the velocity of a column of water moving in a pipe is changed, alternating waves of high and low pressure will travel back and forth in the line. Although the check valve may aid in reducing the effect of surge on the pipe system, it may, through its own action, create a worse wave system that can be damaging to the line. The primary purpose of a check valve is to prevent reversal of flow. Any of the valve types common in the water works industry can be adapted for this purpose; but, under differing hydraulic conditions, one type may be better than the others.

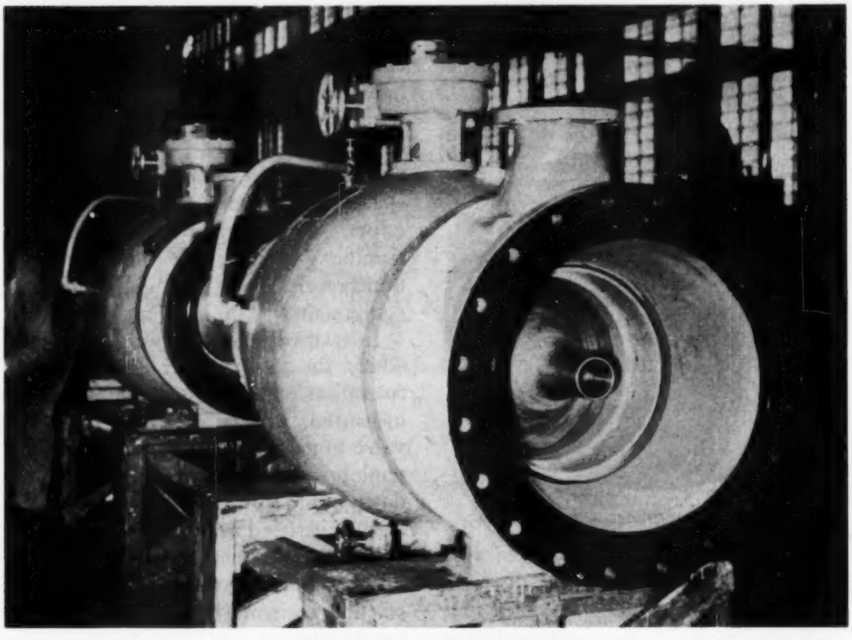

Fig. 2. Larner-Johnson Needle Type Valve

The large sizes are usually controlled hydraulically by the internal-differential method.

Of the many check valves on the market, the most familiar is the swing check (Fig. 3). It can be single hinged (symmetrically or unsymmetrically) and lever and weight loaded or

spring loaded. With either of the last two designs, the loss of head will be increased, because the leaf will be forced down into the stream and the effort necessary to force the valve open will be greater. If, in order to reduce loss of head, a larger valve is selected for a given flow, the velocity will be less and the valve will not open as far. Conversely, if, in order to get the valve open, a smaller valve is chosen, the velocity will be higher and the loss of head will be greater.

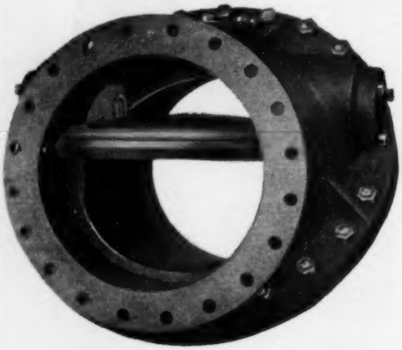

Fig. 3. Tilting-Disc Check Valve

Swing check valves can be hinged symmetrically or unsymmetrically.

If the hinge pins are made of yellow brass, the flap will eventually drop off, because dezincification and friction will combine to ruin the valve.

The great disadvantage of this type of valve is the lack of control over the time of closing. Swing checks are successfully used in numerous manually operated pumping plants where the pump is started against closed gate valves. In such instances, the only hazard is that power failure may cause the check valves to close, with resulting shock. Swing check valves also work satisfactorily in pumping plants connected to well developed grid systems, provided only one pump is operated. If a second pump is utilized in parallel with the first, the stopping of one may cause a damaging metal-to-metal slam on its check valve, but without propagating a water hammer wave.

Some engineers do not trust the newer types of check valves, preferring to rely on the old-fashioned swing check. When they encounter water hammer troubles, they add air domes, requiring periodic air replenishment, or surge pipes, relief valves, or other auxiliary devices that take up valuable space and demand extra maintenance effort. Such arrangements may solve specific problems, but they are often unnecessary if one piece of well chosen equipment will do a comparable job.

In transmission pumping plant lines, where the time of acceleration or deceleration of the water column can be measured, a very fine type of check valve to use is a hydraulically operated, nonlubricated plug valve. In shutting down a plant of this sort, the valve can be so controlled as to close it completely at the instant that the velocity of the water column becomes zero, while, in starting the plant, the speed of opening can be slowed down, so that the compression wave which builds up at the pump when the column is accelerating is reduced to a minimum.

The hydraulically operated internal-differential needle valve previously mentioned can serve a triple purpose as a throttling, check, and pump control valve. The so-called sleeve valve, which is a modified needle type also described earlier, is often used for this purpose.

If a plug or needle valve is used on a pumping installation where the dis-

charge line is very short, it may not be possible to close the valve before the flow of the column reverses direction. In this situation, the valve must be closed very slowly, allowing the pumps to rotate in reverse. There are some pumping plants which operate in this manner. Such valves should not be used if there is a possibility that the shaft sleeves on the pump will unscrew during reverse rotation.

Still another form of check valve is an internally installed, helical spring–operated type in which the disc is at right angles to and moves concentrically with the flow. This type is very effective as a check valve, but the loss of head for a given flow is much greater than for any other kind of check valve of the same nominal size with which the author is familiar.

In a pumping installation where the characteristics of the distribution system require a check valve that closes very rapidly, the basket type, with an expanding elastic "Hycar" * sleeve, does an excellent job (Fig. 4). These valves are marketed in sizes up to 12 in. The variety used at East Bay is plastic lined on the inside. One advantage of this valve is that there is no contact between different metals.

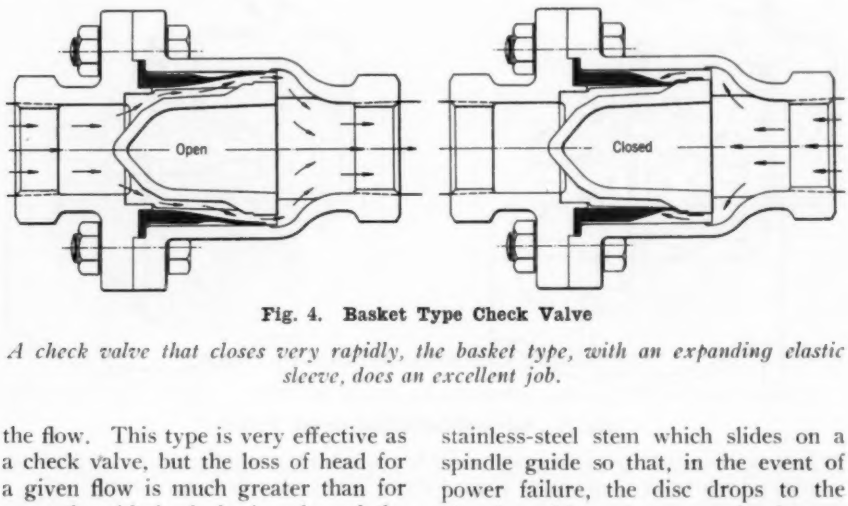

Fig. 4. Basket Type Check Valve

A check valve that closes very rapidly, the basket type, with an expanding elastic sleeve, does an excellent job.

In an automatic pumping installation where the pumps must be started and stopped against closed valves with a regulated speed of opening and shutting, East Bay has successfully utilized a solenoid-actuated, diaphragm-operated, globe pattern valve with the controls built into the assembly (Fig. 5). Internal parts are bronze and the free-floating disc that is pressed up against the head by line pressure has a hollow, stainless-steel stem which slides on a spindle guide so that, in the event of power failure, the disc drops to the closed position almost at the instant that the water column attains zero velocity and before it can reverse. In that respect, this valve is superior to the spring-loaded or lever-and-weight swing check and the loss of head is no greater. (There are 23 electric check valves, sizes 4–16 in., in the East Bay system.)

In situations where swing checks used as dividing valves for combination gravity and transmission pumping to a reservoir give trouble, slow-closing, dia-

* A trade name of B. F. Goodrich Chemical Co., Cleveland, Ohio.

phragm-operated, globe checks have proved to be very successful shockless substitutes (Fig. 6).

The first automatic pump control valves used at East Bay, in the late 1930's, were gates. At that time it was suggested to some gate valve manufacturers that, because there was a trend toward automatic pump control, it might be well for them to market an assembled, hydraulically operated, solenoid-controlled gate. The suggestion was rejected on the grounds that the factories were set up for quantity production of gate valves and were not organized to handle economically a specialty that did not promise a steady volume of consumer demand.

This refusal led to a search for substitutes, and the need for a self-contained automatic pump control valve has been satisfied by the makers of other types of valves, who could start fresh, without the handicaps of tradition. The first pump control gate valves at East Bay wore out in 1–5 years, depending on how often they were operated, whereas pump control valves of other types have continued in service or have been moved to different plants for further service with practically no maintenance work required on the valve proper.

Butterfly Valves

The butterfly valve, in 4–72-in. sizes, is coming into increasing use in general water works practice, while, in special installations, sizes up to 14 ft are employed. This valve possesses a great advantage in having only one moving part. As now built, butterfly valves can compete in price with the best-quality gate valves, provide tight shutoff, require minimum maintenance, and have a long service life.

For absolutely tight shutoff at pressures of less than 125 psi, the synthetic

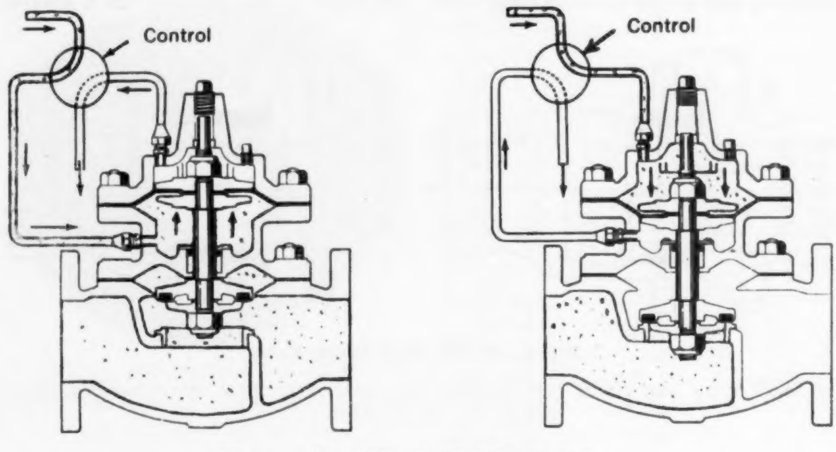

Fig. 5. Solenoid-controlled Check Valve

Where automatically operated pumps must be started and stopped against closed valves, solenoid-controlled, diaphragm globe pattern valves have been used successfully.

or gum rubber–lined valve is available as a staple market item (Fig. 7). This type of butterfly is meeting with increasing favor in filter plant installations. For pressures higher than 125 psi, a variety of metal-to-metal seat arrangements, both adjustable and fixed, can be obtained with very low rates of leakage. Butterfly valves can be used wherever any other type is employed in water works practice, except in pipes requiring a full-size round opening through the valves to permit the passage of lining or scraping equipment.

Butterfly valves may be manually or power driven. The low power requirements make it easy to adapt electric-motor or pneumatic or hydraulic drives of either the diaphragm or piston type to these valves. Automatic operation can be full open or shut, or infinite position between these two. Bodies and discs may be of cast iron or cast steel, shafts of stainless steel or Monel, bushings of bronze, vanes with hard chrome edges, and body seats of Babbitt metal or bronze, depending on the use to which the valve is to be put.

Although a longitudinal section through a butterfly valve may make it appear symmetrically balanced, it actually is not. Of the great variety of valves used in water works, the service application of the butterfly requires the closest scrutiny by both the purchaser and the salesman. Overeagerness on the part of the latter to sell a butterfly valve with a light-weight shaft for a service application requiring a heavier one has resulted in incidents that have created unjustified prejudice against a very fine water works device.

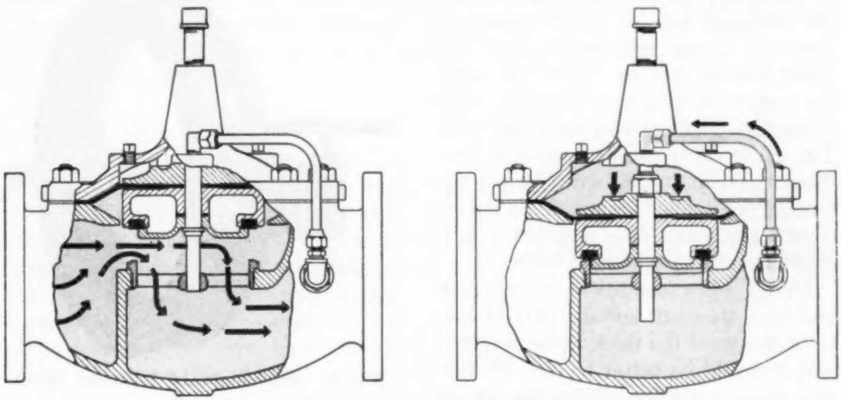

Fig. 6. Slow-closing Globe Type Check Valve

This type has proved a useful substitute where swing checks used as dividing valves give trouble.

Three basic service applications may be classified as follows: [1] a closed system with a limited pressure drop and limited flow, such as at the effluent valve from a filter bed; [2] limited free discharge, such as in a main break downstream from the valve or pump discharge to a dry system; and [3] full free discharge, such as at a valve mounted on the downstream face of a dam. In each of these applications, the

magnitude of the seating, bearing friction, hydrostatic, and aerodynamic or flow torques is different. The countertorque that must be applied to the shaft in each instance determines the size of the shaft. In the closed system, an 18-in. valve, with the disc open 60 deg and an upstream pressure of 50 psi, a downstream pressure of 49 psi, and a flow of 10,000 gpm, will require a dynamic torque of 400 ft-lb to open the valve further. For throttled free discharge, the same valve, with disc open 28 deg, 50 psi upstream, 0 psi downstream, and the identical flow of 10,000 gpm, the dynamic torque required to open the valve further will be 1,200 ft-lb while the torque necessary to close the valve from this position will be 1,000 ft-lb. The same valve, under open-end, free-discharge conditions, with 50 psi upstream, 0 psi downstream, and a flow of 69,000 gpm, will require 6,000 ft-lb to close from this position.

Under some conditions of pressure and flow, the shaft and disc would have to be designed too thick to be practical, and it would be better to use the disc-arm valve, a modification of the butterfly in which the disc is pulled into the open position from the outer perimeter by a tension bar linkage acting through a stuffing box on the top of the valve (Fig. 8).

There are 26 butterfly valves in the East Bay transmission system—two 42-in. and two 72-in. isolating valves that protect free-discharge needle valves in the downstream face of Pardee Dam; two 72-in. isolating valves upstream from the 10,000-hp Pardee turbines; nine 60-in. turnout valves, for isolating an 8,000-hp and a 5,400-hp transmission pumping plant (one of these valves has a shaft heavy enough to permit closing in the stream); three 48-in. isolating valves on the suction lines of three large pumps; and four 36-in. electrically operated and four 42-in. hydraulically operated butterflies, each linked to an 18-in. needle valve, at eight automatic, synchronous stop and relief valve stations established at 20-mile intervals in the 65-in. and 68-in. transmission lines (the discs and shafting of the butterflies are heavy enough for the valves to be closed in the stream). A break in the line downstream from one of these stations would cause an

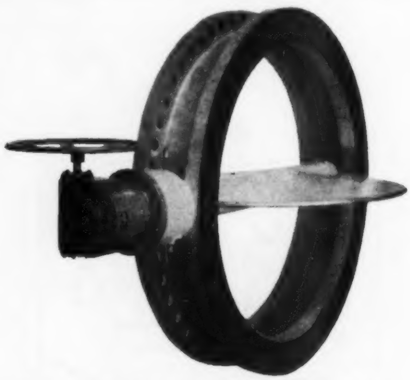

Fig. 7. Rubber-seated Butterfly Valve

For absolutely tight shutoff at pressures of less than 125 psi, this type is available as a staple market item.

increase in flow rate, and the venturi effect through the restricted opening of the valve would create increased differential in the float chambers of a mercury U-tube, triggering a tripping device that would start the butterfly closing at the same time as the needle relief valve began to open.

Although butterflies are often used as free-discharge valves, other types on the market would, more often than not, be better suited for this purpose. Anyone who has ever been near a large butterfly valve discharging freely into a

downstream pipe section under high head while operating through the critical point in its opening or closing stroke will remember a terrifying experience, but, under normal conditions in a pipeline, these valves are silent, efficient, and easily controlled.

The butterfly valve has one great advantage over other types in its short face-to-face installation length. This, together with the fact that, for sizes 30 in. and greater, a butterfly valve can be purchased for less than any other kind designed and equipped for comparable water works duty, is a good argument for the wider use of butterfly valves in large distribution pipelines.

Automatic Stop Valves on Reservoirs

It has been suggested by some civil defense authorities that automatic stop valves be installed on reservoirs in congested areas to conserve storage in the event of a disaster in which the distribution system suffered serious damage. Correspondence and discussions with many water works men have led the author to believe that this arrangement would be highly expensive and impractical for a distribution system. It might even do more harm than good in certain types of disaster where water may be badly needed to put out a fire.

Plug Valves

The plug type valve with one moving part in the valve proper is familiar to every water works man, as it is used in every water service which has a service cock tapped into the main and a curb or corporation cock at the point of service, commonly upstream and just ahead of the meter, if any. Cocks that isolate gages and other forms of instrumentation utilized in the water industry are another application for the plug valve. Still another is the three- or four-way cock used to control pressure on hydraulic cylinders that operate larger valves. The plug valves mentioned are of the dry type and are made of brass when used in water service.

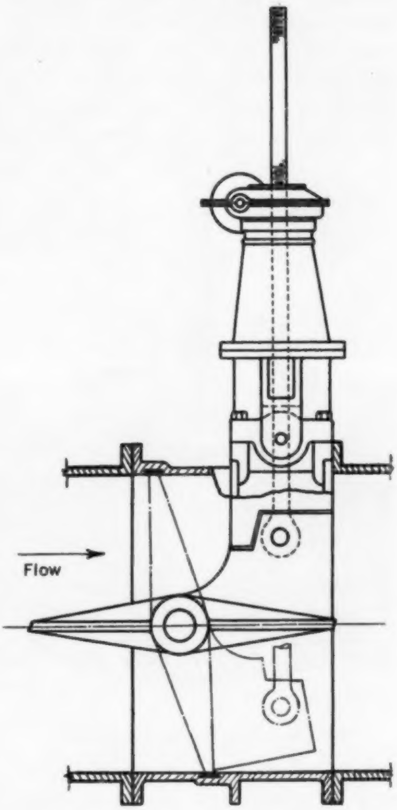

Fig. 8. Disc-Arm Pivot Valve

This type is a modification of the butterfly valve, in that the disc is pulled into the open position from the outer perimeter by a tension bar linkage acting through a stuffing box on the top of the valve.

An all-iron lubricated plug valve is receiving increasing attention from water works operators. It can be obtained

with a plug opening area equal to 90 per cent of the nominal area of the valve in sizes up to 16 in. In the venturi pattern, it is furnished in nominal sizes up to 30 in. A 30-in. venturi pattern valve would have a plug opening area approximately equal to that of a circle of 19-in. radius; a 24-in. valve, 15-in. radius; and a 20-in. valve, 13-in. radius. Thus, the venturi pattern plug valve would have approximately the same opening

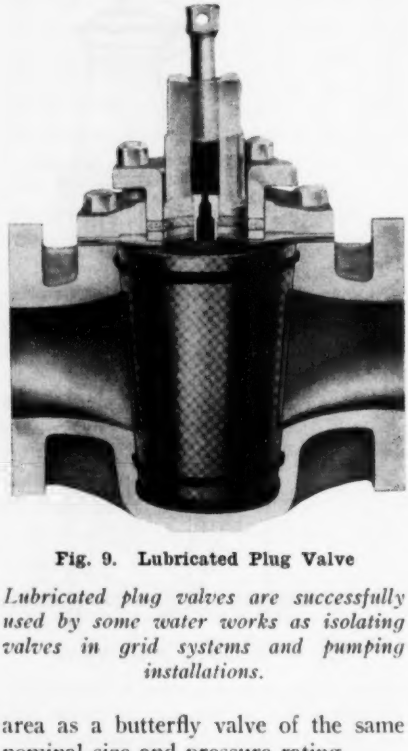

Fig. 9. Lubricated Plug Valve

Lubricated plug valves are successfully used by some water works as isolating valves in grid systems and pumping installations.

area as a butterfly valve of the same nominal size and pressure rating.

The lubricated plug type (Fig. 9) is successfully used by some plants as an isolating valve in grid systems and pumping installations. East Bay employs about 75 such valves, in various sizes, for this purpose in pumping plants and other automatic installations, and about fifteen, in the 16-, 20-, and 24-in. size, as turnout valves from transmission lines. A 24-in. and a 30-in. plug are used as remote supervisory control water-dispatching valves, electrically operated and controlled through leased telephone lines from a central dispatching point 12 miles away. Another 30-in. plug is used as a float-controlled, hydraulically operated altitude valve. A 16-in., 90 per cent open, manually operated plug is doing a fine job as a throttling valve under very severe conditions. Four-way lubricated plug valves are excellent for filter plant control table manifolds, and East Bay has two filter plants so equipped.

The lubricated plug valve installations at East Bay have been very successful. The main difficulty has been in getting operating personnel accustomed to using new equipment; once they become familiar with these valves and note their ease of operation, however, they want more of them. It is important to remember that, if this type of valve works hard or has a tendency to stick, the stuffing box on the top should be tightened—not loosened as with a gate valve—so that an application of grease through the pressure fitting will jack the plug loose. On one occasion, the 30-in. dispatching valve previously referred to was found to be stuck, but it was easily freed by applying grease and operating it manually. Operation from time to time through a partial stroke has prevented further trouble. Although some water works men have expressed fear that the use of these valves would allow grease to escape into the distribution system, no consumer complaint on this subject has been brought to the author's attention during the 14-year period in which East Bay has employed this type of valve.

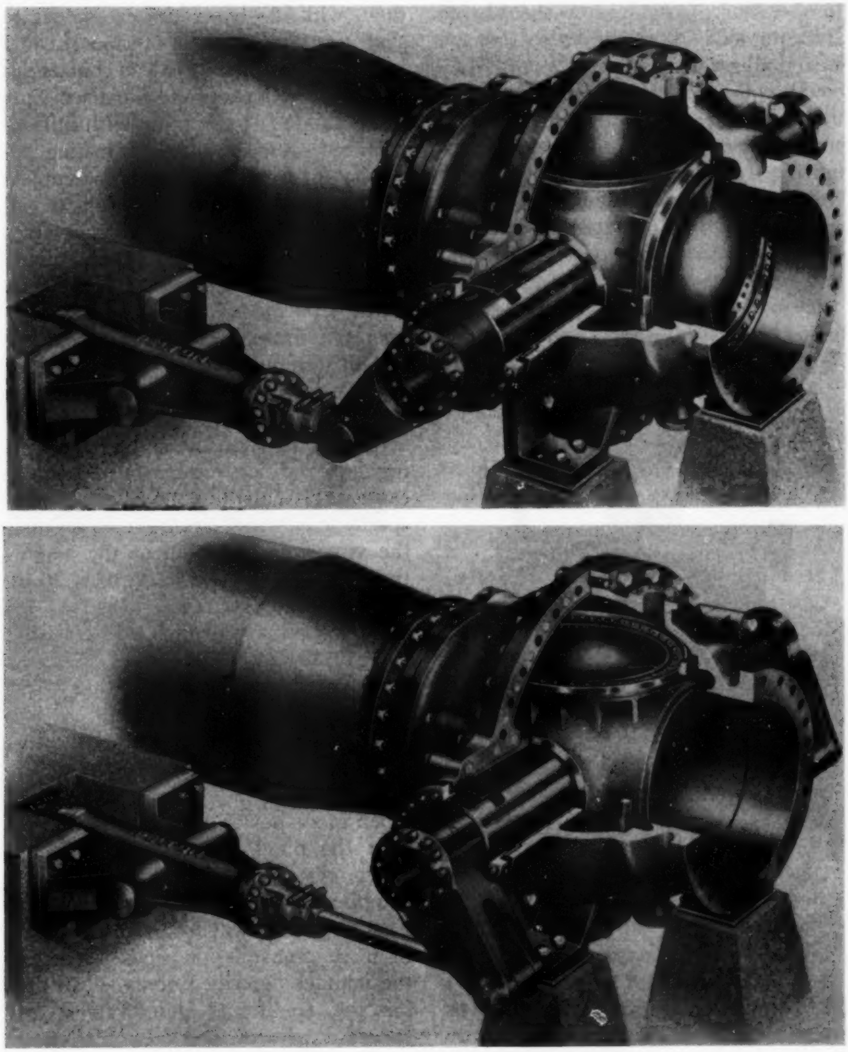

Fig. 10. Nonlubricated Spherical Plug Valve

Top—closed; bottom—open.

The nonlubricated, full-open, conical type of plug valve is another very fine water works valve, which allows smooth, unrestricted flow when fully open. This valve is mechanically jacked up from, or down to, the seat in either the fully open or the fully closed position. Even in the largest sizes, it can be manually operated easily and quickly by one man. (In fact, men accustomed

to operating gate valves by sheer brute strength have been known to damage such a plug valve severely, because they could not bring themselves to believe that a valve, especially one of large size, could be closed so speedily without requiring a crew of laborers to lay their weight against a capstan bar.) The valve can also be operated by water or

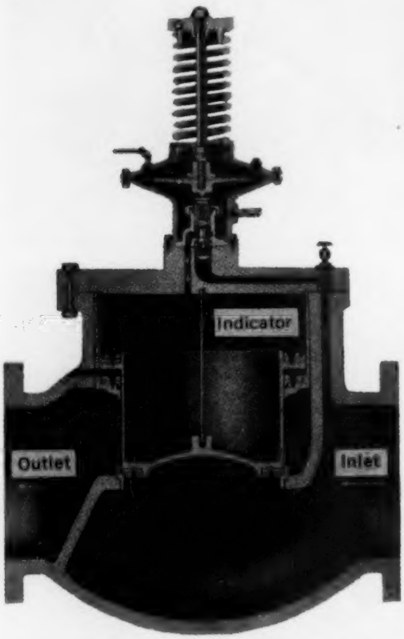

Fig. 11. Globe Pattern Altitude Valve

A piston type is shown.

oil hydraulic power, compressed air, or electric motor. The workmanship in these valves is first class, and a wide choice of high-grade nonferrous metals for mounting in the wearing and seating parts is available, Monel metal being a favorite.

This type of valve offers the following advantages: [1] positive control of valve timing; [2] free, unobstructed flow, with the head loss equivalent to that in a straight piece of pipe of equal length and diameter; [3] no contact between the valve seat and the direct flow of the fluid; [4] operation with full unbalanced pressure, thus eliminating necessity for bypasses; and [5] complete enclosure and full lubrication of all working parts. One of five such valves at East Bay, a 42-in. valve on the tunnel outlet at the upstream end of a 68-in. pipeline 90 miles long, is hydraulically operated through a closed-system air and oil accumulator set. In the event of a break downstream from the valve, the increased flow through a venturi meter actuates a trip mechanism and governing device, which, in turn, automatically causes the valve to close at a fixed speed, regardless of the temperature, the viscosity of the oil, or the magnitude of the break. A 36- and a 30-in. motor-operated valve are used as remote supervisory control rate-setting valves. Two 30-in. valves are employed at strategic locations in a 48-in. transmission line for rapid one-man operation in emergency shutdowns. These valves supplement three of the usual isolating gate valves, which take much more power and time to operate than the plug type. A metropolitan water system with an average consumption about four times as large as East Bay's uses many of these valves in large transmission lines, either in the manner described or as substitutes for the traditional gate valves, but spaced at greater intervals.

The ball valve, a full round opening, nonlubricated plug type, seems to have all of the advantages of other large plug valves and is meeting favor wherever it is used. Mechanical jacking of the plug from the seat before turning is cleverly avoided by setting the plug slightly eccentrically on the shaft, so

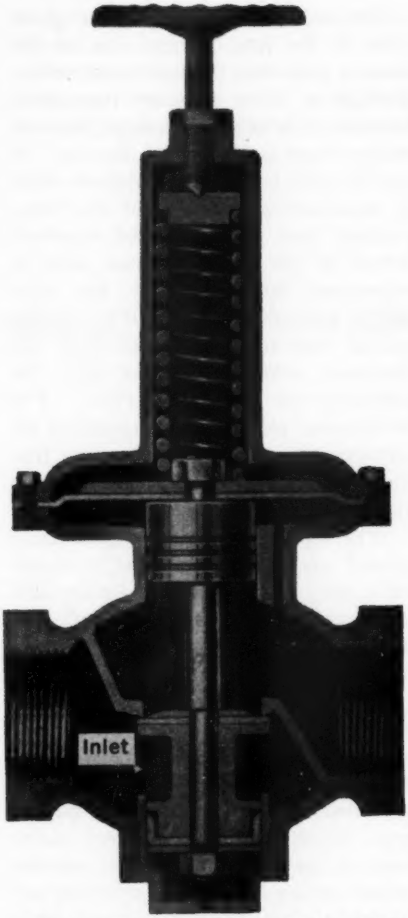

Fig. 12. Pressure-reducing Globe Valve

Most manufacturers adapt the same valve body castings for pressure-regulating, altitude, pump control, and slow-closing check valves by varying the pilot control and diaphragm mechanisms.

that the plug seat and the body seat match, with metal-to-metal contact, when the valve is closed. A 16-in. ball valve used for very severe throttling service in one of East Bay's remote supervisory rate-setting stations has so far given excellent results, whereas a manually operated gate valve was destroyed in this installation in less than a year. A 24-in. ball valve is being employed as an altitude valve on a new 12-mil gal prestressed concrete reservoir.

Another plug type valve particularly adaptable to large, high-head impulse turbine installations is the spherical valve (Fig. 10). Like the ball valve, it has very favorable possibilities for use in the water works industry. The rotating plug contains valve seats and a full-open smooth passage for water flow. The valve seats on both the body and the plug are eccentric to the valve centerline and are adjustable to a tight fit, so that they form a positive seal when the valve is closed.

Globe Valves

Globe pattern altitude valves and pressure regulators (Fig. 11 and 12) are on the market in sizes up to 36 in. in diameter. The globe valves in the East Bay system include 142 pressure regulators, 59 altitude valves, and 21 float valves, 2–16 in. in size.

The globe valve is such a commonplace item that everyone takes it for granted without realizing its widespread importance. There are very few people in the civilized western world who do not at some time during the day operate a globe valve in a water supply system. The washbasin, kitchen sink, shower, and bathtub are all supplied with water whose flow is regulated by some modification of the globe valve. The float valve in the toilet tank and the hose bib in the garden are globe valve patterns familiar to all. Early in the history of the plumbing supply industry, this valve evolved as the practical answer to the need for a device to throttle or regulate the flow of water and steam. In its simplest form, as

either a globe or angle valve, a disc is forced down by a screw against a circular seat. The disc and screw constitute a single moving part in the smaller valves, but, in some modifications of the larger valves, the disc is free to pivot on the end of the stem. As a throttling device, there has never been anything on the market to compare with the globe valve in economy, versatility, simplicity, and rugged durability.

Hand-operated globe valves are less expensive than gate valves of the same size and are very much easier to repair in the line. By removing the head, the stem and disc can be lifted out, and the body seat ring can then be unscrewed for repair or replacement. Because there are no sliding parts except the screw and stem, the wear comes only from wire drawing on the disc and seat ring and does not occur for many years. Hydraulically operated globe valves of either the piston or diaphragm type are just as durable as the manually operated types. Although the driving mechanisms need occasional diaphragm, cup leather, or **O**-ring replacements, the interior metal parts of the valve proper are easily accessible and go for long periods without repairs. A pressure regulator that had received very hard usage over 31 years was recently removed from the line only because replacement parts were no longer available. Hydraulically operated globe valves require very little power, as the line pressure imposed on the upper side and relieved from the bottom side of the diaphragm or piston is sufficient to close or open the valve at a controlled speed. Most manufacturers adapt the same valve body castings for pressure regulators, altitude valves, relief valves, electric pump controllers, and slow-closing checks by varying the pilot control and diaphragm mechanisms.

The one disadvantage of the globe valve is the loss of head due to the devious path that the fluid must follow through it. For pressure regulators, however, this is an advantage, because energy must be dissipated anyway. If a globe valve is used as an altitude valve in installations where all of the water pumped does not reach the reservoir served by the valve (because some is intercepted by consumers), the valve size is generally determined by the required rate of withdrawal from the reservoir, which is higher than the pumping rate to the reservoir. The withdrawal rate can be augmented by introducing a swing check valve into the bypass line around the altitude valve.

Where pumps must be automatically started and stopped against a closed valve, the globe type, solenoid-controlled check valve previously described (see page 1063) is a superior device for this purpose.

Air valves and vacuum valves, often built in combination, are very difficult to classify because there are so many kinds on the market, but most of them are either of the globe, needle, or poppet type, which can be considered variations of one another. Air and vacuum valves are used mostly for relieving entrapped air from the high points in pipelines or for admitting air to the pipeline whenever the pressure inside of the pipe becomes less than atmospheric.

Large quantities of air enter the pipeline systems when breaks occur or when lines are opened for connections or repairs. When such a line is again placed in service, the air works its way to the high points, and, if it is not entrapped and released through air valves before it reaches an altitude valve or pumping station, it sometimes causes damage to

equipment and inconvenience to consumers.

Vacuum valves are often unnecessary if pipes are lined and coated with Portland cement mortar or if they are buried

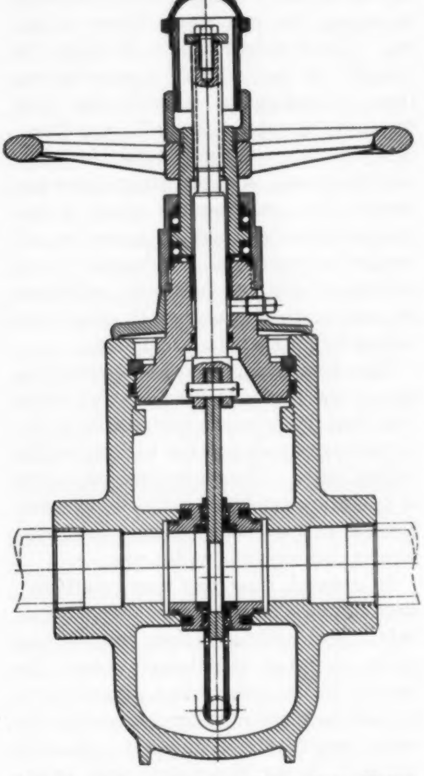

Fig. 13. Ring Follower Type Gate Valve With O-Ring Seats

This bubble-tight valve can be put through thousands of opening and closing operations without showing signs of wear or damage to the O-rings.

in well compacted material. Data obtained from experiments on a 48-in. steel pipe with a wall thickness of $\frac{1}{4}$ in. and on a 36-in. steel pipe with a wall thickness of $\frac{3}{16}$ in. show how Portland cement lining and coating strengthen large-diameter pipes to a remarkable degree against collapsing (*1*).

Early in 1951, three 54-in. dipped and wrapped tunnel outlet pipes with $\frac{7}{16}$-in. wall thicknesses, buried parallel to each other, were subjected to a vacuum of 29 in. of mercury or 14.2-psi external pressure for about 40 min without apparent damage. The same pipes, if unburied, would have collapsed under such a vacuum.

Gate Valves

Gate valves are installed by the thousands throughout the land, but they remain almost always in the wholly open position, because most of them serve as isolating valves in distribution grid systems or as protection for operating valves. A smaller number are employed as dividing valves between pressure zones, remaining closed except for inspection or an occasional emergency.

Water works gate valves are of either the solid-wedge or the double-disc, parallel-seat type. The stems can be rising or nonrising, but only the nonrising-stem valves are practical for direct burial in the ground. Even though these types have evolved through experience and tradition as the practical water works grid system valve, both have serious faults and leave much to be desired in the way of improvements in design. Because they are so common in the water works industry, they are often used as operating valves where other types would serve a great deal better.

Efforts to overcome some of the disadvantages of the gate valve have resulted in the development of the ring follower, paradox, and ring seal gates as main stops for isolating powerhouse water turbines and free-discharge operating valves in sluiceways and dams.

These gates have been built to various designs and in large sizes for the US Bureau of Reclamation.

An interesting gate valve pattern, manufactured on the West Coast, is finding wide acceptance in natural gas and oil pipelines and in refinery use. It is of the ring follower type, with stainless-steel interior parts and O-ring seats, which make possible a bubble-tight valve that can be put through thousands of opening and closing operations without showing signs of wear or damage to the O-rings. This valve, which is successfully displacing other types, can be purchased in sizes up to 36 in. at prices competitive with some valves used for operating purposes in the water business (Fig. 13).

Throttling is the most severe service to which a valve can be subjected. Of all the valves utilized in this way, the double-disc gate is the least durable, and it should generally be limited to service as an isolating valve, an application in which, owing to its relatively low initial cost, practical experience has found it to excel. If a gate valve is intended for throttling service, the solid-wedge variety, with close-fitting guides, should be selected. Square-bottom and beamed-waterway double-disc types are widely used as wash water valves in filter plants, under conditions of low head and velocity.

The beamed-waterway double-disc valve is equipped with bronze-faced beams located in the downstream part of the valve body. Bronze strips on the downstream disc match and are opposite the beams, and the disc and beam facings are flush in the same plane with their respective disc and seat rings. This arrangement prevents the disc from tipping obliquely into the seat ring and very effectively prolongs the life of the valve. The square-bottom valve has shoes that are attached to the downstream disc at three points and slide on tracks, two in the valve body and one in the bonnet. In this manner, the disc is held away from the seat until the shoes slide off the tracks at the end of closing travel and allow the disc ring to engage the seat ring without scraping. These valves can be of either the "single" or the "double" square-bottom type, according to whether the flow through the valve is to be in one direction or two. Although the beamed-waterway and square-bottom arrangements save wear on the seats, a disproportionate amount of power is still needed for operation, and bypass valves and gear trains or hydraulic cylinders are necessary accessories to most gate valves larger than 16 in. in size.

Gate valves can be power operated by any of the methods used for any other type, but the power requirements of the former are much greater because of the sliding parts. The most common means of operation are hydraulic cylinders and electric motors, but pneumatic operation is coming into wider use.

In general, East Bay uses nonrising-stem double-disc valves for direct burial only. For isolating valves in pumping plants or other installations where the valve is in the open or in a pit and there is sufficient room to accommodate the extra length, the rising-stem valve is utilized. Some 90 per cent open, lubricated plug valves are also employed for the latter purpose.

The solid-wedge type has two moving parts in the valve proper, both of which are subject to unlubricated sliding friction, where the square- or acme-threaded stem screws into the wedge and where the wedge guides slide on close-fitting guides in the valve body. The wedge is usually of solid brass or bronze or, like the body seat rings, brass

or bronze mounted. The wedge faces do not come in contact with the seats until the valve is closed. If the valve remains in the open position for a long period in a grid system carrying water that causes lime or other solid matter to deposit or tubercles to develop in the recess between the seats, the valve will not close completely and too much effort to force it will break the stem. Also, if this valve is installed in the tightly closed position when the temperature is high and is left closed after cold water has been introduced into the system, it may be very difficult to break the valve loose to open it. The valve has a tendency to stick in the closed position even when there is no temperature change. A number of manufacturers produce these valves only in the smaller sizes, which are used by some large water works systems in great quantity. The solid-wedge valve is favored in some industrial, refinery, and steam plant applications. An advantage of the solid-wedge gate lies in the fact that it can be installed and operated in any position—horizontally, vertically, upside down, or with the leaf in a horizontal plane. (East Bay discontinued the use of single-wedge gates about 15 years ago because they are difficult to repair, especially in setting them up in machines for accurate refacing so that the wedge faces on the disc and body could be fitted true and tight.)

The double-disc, parallel-seat gate is an awkward mechanical device, with four to ten moving parts in the valve body proper, each of which slides or scrapes without lubrication against some other part. Double-disc gate valves are designed primarily for use in the vertical position with the stem upright, but they can be operated in the horizontal position. The loose parts of the wedging mechanism work best when hanging in the vertical. Valves 16 in. and larger, installed horizontally in horizontal pipelines, should be equipped with tracks, rollers, and scrapers. The installation of double-disc gates in vertical pipelines should be discouraged, even if tracks are placed in the bonnet to support the edge of the lower disc. Double-disc valves will not operate upside down or at any angle with the stem below the horizontal, because the wedging mechanism engages and jams the discs against the seats. Moreover, accumulations of solid matter trapped in the bonnet will interfere with the operation of the valve.

Nearly every manufacturer has his own method of spreading and wedging the discs against the seat rings in the closed position. The advantages of some of these methods are subject to argument. A single good standard design for a wedging device in gate valves is badly needed. For valves 12 in. or smaller, this design should permit the stem to be changed with the discs wedged closed and the line under pressure.

As the two discs hang loosely inside the valve bonnet, the downstream disc edge tips into the waterway and gouges into the seat ring at a slightly oblique angle when the valve disc passes between the open and closed position, causing uneven wear on these parts. If a double-disc valve is allowed to remain in a partly open or throttled position for any length of time, the constant vibration or chattering of the discs in the stream soon causes wear in the small links required in some designs to hold the leaves parallel; when the links finally wear through and come off, enough displacement of the discs often occurs so that the hooks and wedges drop out and are carried away in the stream. Gate valve parts have occa-

sionally been found at considerable distances from the places where the valves were located.

In the double-disc gate, the outside of the two discs and the protruding end of the stem are the only portions of the moving parts that can be seen without disassembling the valve. The other parts are hidden from view between the leaves or in the bonnet of the valve.

East Bay recently sent a questionnaire to some gate valve manufacturers and large users in order to establish a cross section of opinion on what constitutes good practice for gate valves equipped with grease cases and intended for direct burial. Not only were the answers conflicting, but some manufacturers even contradicted themselves when the same question was asked in a different way. There appeared to be no standard practice based on factual observation of or experience with grease cases among either users or manufacturers. Some of the latter seemed to have an unsympathetic and unrealistic attitude toward the users' problems and gave the impression that, as long as gate valves are made and sold in the traditional manner, the user should be satisfied with what the market has to offer. One or two suggested that, even though the grease was driven from the case by water under pressure, the valve could still be operated.

It must be concluded from the questionnaire returns that manufacturers and users of gate valves do not know whether or how long an integral type of gear case remains free of water after the valve has been installed. The attitude seems to be that what cannot be seen cannot be known and what is not known is not important. Yet what assurance is there that, in an emergency, a large distribution line gate valve can be closed if it has remained untouched for a long period, with discs forced out against the top of the body seat rings by tuberculation and corrosion products?

Based on experience during the past few years, very rigid specifications on gate valves have been drawn up by the East Bay Dist. These specifications require delivery of the larger gate valves to East Bay shops for dismantling and inspection. Any valve that is not in compliance with the specifications must be corrected.

Conclusion

A variety of good check valve types are available on the market, some one of which, in any given situation, is better than the others.

The traditional gate valve, up to 16 in. in size, has earned top consideration in the water works industry as an isolating valve.

The traditional gate valve is the least durable and the most difficult to operate of all valve types practical for water works service. Users of valves in sizes 24 in. and larger would do well to consider the application of various types other than gate valves, regardless of whether they are intended for isolating or operating purposes.

Acknowledgment

The cooperation of valve manufacturers in furnishing illustrations used in this paper is gratefully acknowledged. Names of manufacturers have been omitted throughout, in order to avoid the implication, erroneous in some instances, that the same type of equipment is not available from other firms.

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Wood Stave Pipe in Water Works Installations

By John W. Cunningham

A paper presented on May 27, 1954, at the Annual Conference, Seattle, Wash., by John W. Cunningham, Cons. Engr., John W. Cunningham & Assocs., Portland, Ore.

THE production and use of wood stave pipe has passed its peak, and it probably will never again find general employment in water works service, although its production will continue for special applications. This paper is intended more as a historical record than as a guide for future design and installation.

Wood pipe in the form of bored logs was used in Europe as early as the seventeenth century and, in this country, before the Revolution. Later these logs were reinforced to withstand greater pressures by winding them with steel bands. The author recalls visiting a plant in Olympia, Wash., in 1901, where there was a substantial production of turned and bored fir pipe reinforced by flat steel straps. Bored pipe was essentially uneconomical as it wasted the best part of the log and was limited to small diameters and short lengths. This disadvantage led to the development of fabricated pipe, built up from staves with steel bands to give the necessary strength against bursting. Wood stave pipe was produced in two forms. For the smaller diameters—generally speaking, 18 in. or less, but occasionally up to 32 in.—the pipe was built up in the shop and the reinforcement was wire, wound spirally around the pipe by machine and under tension. The pipe was therefore called "wire wound" or "machine banded." Such pipe could be readily laid by labor of moderate skill and was suitable for distribution system use, as well as for smaller transmission mains. Larger-size pipe took a different form. Staves were produced in the shop, but the construction was done in the field by skilled workmen. Joints between individual staves were staggered, and the pipe as a whole was without joints, giving it the name, "continuous-stave" pipe. For field installation, wire winding was impractical and the reinforcement took the form of threaded steel bands connected by malleable-iron shoes. In water works practice, this pipe was best adapted to transmission lines. It also had a wide use in conveying water for irrigation and mining and for power penstocks.

Wood stave pipe was produced and used in all parts of the country. In the East, the materials were white pine, cypress, and sometimes tamarack. The greatest production and widest use, however, was on the Pacific Coast, owing to the availability and low cost of highly suitable woods like fir and redwood. These are strong, clear, and straight grained and could be obtained in any size and length. Both fir and redwood, particularly the latter, are resistant to decay. Of the two, fir was cheaper. The wide use of wood pipe in the West was due partly to the

absence of iron and steel industries. Cast-iron pipe and the plates for steel pipe had to be shipped from the East. Furthermore, the country was developing rapidly, the cost of capital was high, and permanence of water supply systems was secondary to low initial cost. Public water supplies for the smaller municipalities would have been postponed many years if wood pipe had not been available.

The terrain of the western states, with streams of excellent quality at the higher elevations, led to a large proportion of gravity water supply developments, requiring long transmission mains. The flexibility of wood pipe enabled it to meet varying topographic and head conditions, and the possibility of transporting staves where there were poor roads or none at all gave an advantage to the continuous-stave type. In the same period there was a great wave of irrigation development, and continuous-stave construction met the requirements of siphons, pipelines, and flumes.

The peak production and use of machine-banded pipe occurred about 1910. Very substantial production continued up to about 1930, but since that time the decline has been very rapid. Under some circumstances, such as those prevailing during World War II or in places like Alaska, the sale of wire-wound pipe has been stimulated, but future use will probably be limited to the conveyance of chemical solutions, paper stock (where metal is objectionable), or abrasive materials (where wood has superior wear resistance), and to other special applications.

The peak production of continuous-stave pipe came later, about 1925. With ups and downs, it has declined since then, although it must still be considered competitive in certain instances—for the most part, outside of the municipal water works field. The manufacturers of wood pipe, both in the fir and in the redwood areas, have also produced wood stave tanks, as a side or main item.

Pipe Design

The design of wood stave pipe for a particular condition and head is by no means a haphazard operation. Stave thickness depends upon head and is selected in accordance with both theory and experience. Band spacing is carefully calculated, usually on the basis of a tension of about 15,000 psi in the steel and a bearing of 800 psi between the band and the wood with a contact width equal to the radius of the band. Malleable-iron shoes have sections calculated theoretically and confirmed by tests.

The hydraulic characteristics of wood pipe are superior to those of most other materials. Many tests have been made, and the data and coefficients are completely set out in a classic paper by Fred C. Scobey (*1*). Continuous-stave pipe can be laid with smooth curves, both horizontal and vertical. Tapered transition sections can be constructed of the same material, and connections of all kinds can be made without difficulty. Pipe is easily tapped under pressure. The size and spacing of bands can be readily varied to meet closely the head to which any section is exposed. An objection to using wood pipe for distribution service is that a dissimilar material, cast iron, must be employed for fittings.

Manufacture and Installation

Staves for either type of wood pipe should come from the higher grades of

lumber, straight grained and free from through knots or other imperfections. If fir is used or the staves are untreated, the wood must be all heart stock. Sap wood, with a coarser grain and less resin, is found to have a much lower resistance to decay. Staves are purchased as commercial sized lumber and are milled to exact and uniform dimensions in special planers, giving accurate curvature and radial edges. One edge has a bead and the other a groove, insuring alignment and serving to some degree as a water stop. Staves must be kiln dried to a minimum dimension, as tightness depends on subsequent swelling. In recent years an increasing proportion of fir pipe staves has been creosoted by a pressure and vacuum process after milling and prior to assembly. Incision of the staves in a regular pattern has been found to improve penetration by the creosote.

Machine-banded Pipe

Owing to the process of selection and to the cutting out of knots and imperfections, stave stock has varying lengths. These are sorted and the machine-banded pipe is assembled from them in random lengths of 6–20 ft, which are held by clamps. The banding wire is anchored by stapling and by a number of starting wraps, and is then wound on spirally under considerable tension. At the end of the run it is again given several wraps and stapled. The wire is also stapled to the pipe at intervals of about 18 in. Joints for the wire-wound pipe are of two general types. "Inserted-joint" or "tenon" pipe has one end bored out on the inside and the other end milled down to the same diameter. This gives a bell and a spigot, each with half the stave thickness. An advantage of this type of joint is that the uniform thickness permits it to be saturated to the same extent as the rest of the pipe. A disadvantage of the joint is its mechanical weakness. For higher heads, wire-wound pipe is always jointed with a separate "collar" (Fig. 1). The two pipe ends are milled down only enough to give uniformity of diameter, and the collar, 6–8 in. in length, is driven over one end of the pipe prior to shipment. Collars are reinforced with wire wrapping or with bands and shoes.

In the field, the trench for machine-banded pipe is graded carefully, with

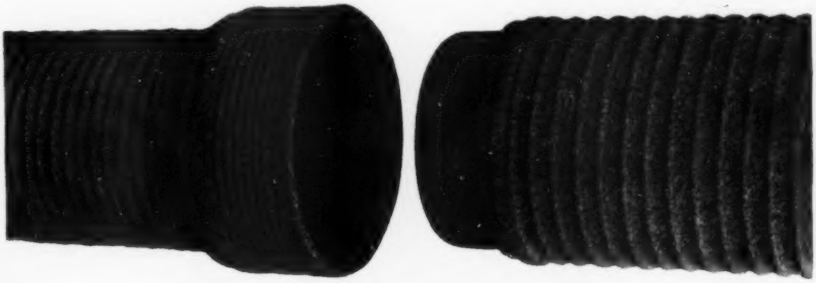

Fig. 1. Machine-banded Wire-wound Pipe

A collar joint is used for high heads.

bell holes, and the sections of pipe are driven together, using a follower plug and a sledge or wooden ram. Wood pipe is never completely tight immediately after installation, and must be filled with water and held under light pressure until the staves have swelled into full edge contact and the joints or collars have tightened up. Careful and patient handling is required during the priming and testing period if a successful installation is to be secured. Contractors or workmen sometimes try to hasten the process by premature calking of leaks or by putting sawdust into the line. They have even been known to use horse manure, which is scarcely suitable for water supply facilities.

Continuous-Stave Pipe

For continuous-stave pipe (Fig. 2), the staves are milled in exactly the same manner as previously described. After knots and imperfections have been cut out, the staves are produced in random lengths. Sorting is done only in the field. As there are no regularly spaced joints, a tight end joint between individual staves is necessary. This is provided either by galvanized metal plate water stops or by malleable cast-iron joints. The ends of the staves must be milled in advance to fit the particular type of joint used. The reinforcing bands for continuous-stave pipe are steel rods in sizes from $\frac{1}{2}$ to $\frac{7}{8}$ in. or even larger. Companies specially equipped for the purpose make the rods by upsetting them to a button head on one end, rolling a thread on the other end without upsetting, and then bending to the proper radius. The full circumference of the pipe is covered by bands in one or more pieces, depending on the pipe diameter.

Fig. 2. Continuous-Stave Pipeline

This 52-in. line formed part of the Seattle, Wash., system.

The bands are connected at the ends by malleable-iron shoes that receive the head and the nut on the adjustable end.

Assembly or building of continuous-stave pipe in the field should preferably be done by experienced workmen, especially if curvature is involved. After having been sorted, the staves are laid on supporting cradles and steel pipe forms, with the joints on alternate staves staggered 2 ft or more. Careful handling is necessary to avoid damage to the corners or ends of the staves or beads. A few bands are placed to hold a section together. The staves are then driven in endwise with a sledge and hardwood driving bar (Fig. 3). Tongues or malleable joints are inserted in the stave ends (Fig. 4), and the next section is assembled in the same manner. Pipe must necessarily be assembled in a straight line. Curvature is introduced later by pushing sections over from the tangent by means of pry bars, jacks, or tackle. This procedure always results in separation of joints on the outside, and the staves must be redriven as the work progresses. The initial banding of the pipe is followed by the placing of additional bands at proper intervals. Bands become bent out of true curvature in shipping and handling. As

Fig. 3. Building Continuous-Stave Pipe in Field

A few bands are put in place to hold the pipe section together, and the staves are driven in endwise.

they are cinched, any kinks present are taken out, and the bands are uniformly seated by light hammering, which also redistributes the cinching stress around the circumference.

Continuous-stave pipe, like the machine-banded type, must be filled and allowed to swell gradually before it is exposed to full head and before any attempt is made to calk points of leakage. Depending on the condition of the staves and the weather, the period for priming and "taking up" may vary from a few days to 2 weeks or more.

Factors in Service Life

The service life of wood pipe may be controlled by the staves, the steel bands, or possibly the joints. Conditions favorable to stave life may be unfavorable to band life, and vice versa. The bands are rapidly corroded in either acid or alkaline soils or by salt water. The methods of protection are the same as those used for other steel products, but the particular form makes protection rather difficult. The wire for wire-wound pipe is galvanized, and, after completion, the untreated pipe is usually dipped in asphalt and then rolled in sawdust while the asphalt is still warm. This gives some added protection. Creosoted machine-banded pipe is not given this treatment because the asphalt will not stick to the treated staves. If the pipe may be exposed to sea water or a similar environment, copper or stainless-steel wire is used for wrapping.

Bands for continuous-stave pipe are bundled and dipped in asphalt or coal-tar compounds after rolling. As these bands get rather severe treatment during pipe construction and cinching, specifications require that they be recoated after assembly, or at least touched up where damaged. This tedious and difficult operation is seldom done thoroughly.

The decay of the staves is a result of fungus growth within the wood. Wood has almost indefinite life if it is either thoroughly dry or completely saturated. Because the first condition is, of course, impossible to achieve in water pipe, the longest life is obtained with the closest possible approach to the latter condition. This is brought about when the interior pressure is large enough to produce saturation and the loss of moisture from the outside is prevented. The ideal situation probably exists in a line that is under 200 ft of head or more and is buried in a tight clay soil free from organic material. It is commonly observed that the low-head portions of a wood stave line deteriorate faster than those under high heads, and that gravel and open soils are adverse to long life. The worst condition is exposure to peat or vegetable mold already carrying the spores of the fungus growth that produces rot. Another factor is temperature. Wood stave lines have a longer life in cold or temperate climates, which retard fungus activity, than in warm climates.

Wood pipe, particularly the continuous-stave type in large sizes, is often laid on cradles aboveground. Such lines suffer from evaporation to the air on the exterior, especially during the summer, and may deteriorate rapidly. When the head is sufficiently high, however, some exposed lines enjoy a very long life. The optimum condition is sufficient pressure to make the pipe sweat continuously on the outside, insuring saturation. The passage of water through wood is much more

rapid if it occurs parallel to the grain rather than at right angles to the annular rings. On one irrigation siphon, flat-grain staves were used for the high-head portion, while vertical-grain staves were employed under lower heads in order to get some uniformity of saturation.

stock. In recent years such stock has become more and more difficult and costly to obtain. Another objection to sap wood is the reduced structural strength, particularly in shear parallel to the grain. Staves sometimes fail by shear along diagonal grain due to compression. Either vertical- or slash-grain staves are preferable to quarter-sawed or diagonal grain.

Fig. 4. Jointing of Staves

The staves are pried apart and malleable joints are inserted in the ends.

Redwood has a considerable natural resistance to decay. In fir, the heart wood, which contains a high proportion of resin, resists decay, but the sap wood deteriorates rapidly. As previously mentioned, it has been customary to specify that untreated wood stave pipe be made from 100 per cent heart

The heavy asphaltic-dip treatment given to wire-wound pipe is an unquestionable advantage in retaining saturation. For continuous-stave pipe, various paints or inhibitors have been applied to the outside, with indifferent

success. Without doubt, the best protection, and one that has been widely accepted by fir pipe manufacturers, is pressure creosoting of staves after fabrication. It is important that the drying prior to creosoting and the creosoting itself be done with the utmost care and under thorough inspection. Too rapid drying may cause "case hardening" and lock in moisture in the interior of the stave. Incision of staves, referred to earlier, is undoubtedly an improvement, in that it permits deeper and more uniform penetration by the creosote. Other types of preservative treatment have been tried but have generally proved inferior to creosote because their components are soluble salts that tend to leach out.

A consideration when creosoted pipe is used for public water supply is its effect on water quality. The creosote initially does impart a taste to the water and, in combination with chlorine, may be quite offensive. Experience has shown that the taste and odor can be reduced at the outset by ammonia. Furthermore, it is rapidly removed by flushing the line. There is seldom any complaint if a line can be continuously flushed and the water wasted for a period of 2 weeks or more before it is put in service.

Pacific Northwest Experience

Wood stave pipe has been used very extensively by municipalities of all sizes throughout the Pacific Northwest, in both the United States and Canada. The early water systems were predominantly privately owned. In the larger communities, even after the main system had been acquired by the municipalities, there were fringe areas and real estate developments where water facilities were being privately installed. In these instances, and also in the smaller communities, first cost was the major consideration, with capital at a premium. Furthermore, a very active promotion effort was made by the wood pipe companies, using the potent argument that local industry should be patronized instead of sending the money east for cast-iron or steel pipe.

At Seattle, Wash., practically all of the original transmission and feeder lines, as well as the distribution system, were wood stave pipe. In 1925 there was more than 100 miles of wood pipe in the distribution system, although, even at that date, all replacements were cast iron. In 1952 there remained about 22 miles of wood pipe in distribution sizes, most of it having been acquired when fringe areas were annexed. Seattle still has 23 miles of continuous-stave transmission and feeder lines in sizes 48 in. and larger. The last important wood line was laid in 1934. The later lines are of creosoted fir, laid aboveground on cradles. They are frequently inspected and are given a spray treatment with creosote every 2–3 years. Other maintenance costs are nominal and the lines are rendering good service.

Tacoma, Wash., in the early days was strictly a wood pipe town. The major portion of the distribution system consisted of machine-banded pipe. The Green River gravity system, completed in 1913, with an original capacity of 44 mgd, was entirely of continuous-stave construction. Different sections of this line have given widely varying service, depending on heads, soil conditions, and other factors. The replacement period extended from 1924 to 1952, so that the service life ranged from 12 to 39 years.

All replacements have been with other materials.

Portland, Ore., has never used wood stave pipe, except under special circumstances. The city's original supply line, built in 1894, was of steel. Systems in fringe areas annexed since then have contained some wood pipe, which has been replaced with cast iron. Only a very small amount of wood pipe is now in service.

At Vancouver, B.C., the supply and transmission lines are owned by the Greater Vancouver Water Dist., and water is wholesaled to a number of municipalities. The district has owned or installed approximately 12 miles of wood pipe in sizes up to 60 in. As elsewhere, experience has varied, but properly installed, untreated pipe has served at least 20 years.

Other cities with extensive wood pipe experience include Bellingham, Everett, Port Townsend, Port Angeles, Aberdeen, and Hoquiam, Wash.; Astoria and Coos Bay, Ore.; and a great many smaller communities. Important wood stave supply lines in these cities are continuing to give good service and have justified their selection at the time they were built.

In general, experience in the Northwest confirms the statements previously made regarding the factors controlling pipe life. The most rapid deterioration has occurred where there was inadequate saturation, due either to insufficient head or to conditions that permitted rapid loss of moisture from the outside of the staves. Stave life has been decreased where there was lack of care in backfilling and where topsoil, vegetable mold, or decaying wood came in contact with the pipe. Other things being equal, a deep trench has proved better than a shallow one, and pipe laid on or above the ground surface, with soil banked around and over it, has had a short life.

Occasionally band rather than stave life has been the controlling factor. At Aberdeen, Wash., a 54-in. wood stave line was laid in 1937 across an area now diked but originally subject to tidal overflow, with soil high in organic material and probably salty. Band replacements became necessary after only 7 years of service and have since been a continuing expense. On the other hand, at Everett, Wash., the original bands of pipe laid in 1916, largely aboveground, are now serving with a second set of staves.

Studies on Service Life

Recent literature on wood stave pipe is nonexistent. The JOURNAL has carried a number of papers on the subject, but the present article is the first one published since 1932. An important early contribution was made by A. L. Adams (*2*) in 1907. An exhaustive study of wood stave pipe life conducted by D. C. Henny was reported (*3*) in 1915. Henny's conclusions are as valid today as when they were written and deserve to be quoted:

Conditions	Life yr
Fir pipe, uncoated, buried in tight soil	20 (avg)
Fir pipe, uncoated, in loose or organic soil	4–7
Fir pipe, uncoated, in air	12–20
Fir pipe, well coated with asphalt, in tight soil	25
Fir pipe, well coated, in loose or organic soil	15–20
Redwood pipe, uncoated, in tight soil, sand, or gravel	over 25

At the time Henny's paper was written, there was little or no expe-

rience with pressure creosoted pipe. Experience has shown that creosoted pipe, buried in tight soil or exposed to air with subsequent spray applications of creosote, will have a life of 35 years. As already pointed out, however, many variables are involved, and the spread between minimum and maximum life experience is very great.

Rise and Fall of Wood Pipe

A period of only about 60 years spans the development of wood stave pipe, its peak of production and use, and its subsequent decline to its present status as a material for special application. It must be regarded as a product based on sound engineering principles. For watertightness, it depends on wood, a material that was cheap, available, and flexible in production. For strength against bursting stresses, it depends on steel, and the principle and methods of prestressing were known and applied many years before the current revival of interest in the subject. Wood stave pipe embodied careful and competent engineering design, and the problem of weakness in the joints was quite well solved in later years.

There are several reasons for the decline in the use of wood stave pipe: The cost of rough lumber has increased more rapidly than that of cast iron, steel, concrete, and other competing materials. At the same time the quality of available stock has fallen off. Furthermore, wood stave pipe is a fabricated material involving relatively high labor costs and is not adapted to full machine production. In matters of design and utilization of material, wood stave pipe reached its peak some years ago and has since been a static product, while other types of pipe have been greatly improved—cast-iron pipe is now produced centrifugally; welded steel pipe has superseded the former riveted joints; the technology of concrete has developed considerably, and many advances in design and production methods for concrete pipe and pipe joints have been made; finally, asbestos-cement pipe has come into use. Nevertheless, wood stave pipe still has an extensive field of service, though generally outside of the area of public water supplies.

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Elbow Meter Performance

By Donald C. Taylor and Murray B. McPherson

A contribution to the Journal by Donald C. Taylor, Research Asst., Hydrodynamic Lab., Massachusetts Inst. of Technology, Cambridge, Mass., and Murray B. McPherson, Assoc. Prof. of Civ. Eng., Lehigh Univ., Bethlehem, Pa.

IN designing water treatment facilities, some engineers have specified that certain elbows in the plant piping system be tapped, before installation, for possible future use as elbow meters. Although a distinct, reliable head-discharge relationship will be obtained for a given elbow meter installation, a high degree of accuracy can normally be assured only when the meter is calibrated in place. The head-discharge relationship is a function of bend and cross-section radii and is affected by the location of piezometer taps, upstream and downstream piping, and probably surface roughness and other factors.

As it is often impracticable to field calibrate elbow meters, a reasonably accurate basis for predicting discharge characteristics, as independent of piping arrangement limitations as possible, would be very desirable. Available meter data have been reconstructed, correlated, and extended by the authors. By changing the location of piezometer taps from a station midway around the bend to one a quarter of the distance around it, more reliable results have been obtained, relatively uninfluenced by the piping and type or geometry of the elbow. This presentation is restricted to the flow of water in 90-deg flanged elbows, except for data from two bell joint elbows.

Piezometric-Head Distribution

The transverse piezometric-head gradient in two-dimensional curvilinear liquid flow arising from centrifugal effects can be expressed, in general, as:

$$\frac{\partial h}{\partial n} = \frac{v^2}{gn} \qquad (1)$$

in which h is the piezometric head (pressure head plus elevation), n is the radius of streamline curvature, v is the tangential velocity at n, and g is the acceleration due to gravity. Combining this expression with the frictionless (potential) energy equation differentiated with respect to a change in streamline radius:

$$\frac{\partial}{\partial n}\left(h + \frac{v^2}{2g}\right) = 0 \qquad (2)$$

and integrating, the result is an expression with the velocity in terms of the radius of streamline curvature:

$$vn = \text{constant} \qquad (3)$$

Many investigators have found that the velocity distribution in bends of both circular and rectangular cross section tends to approach this theoretical distribution, the velocity decreasing with increase in radius of curvature. As early as 1911 Jacobs and

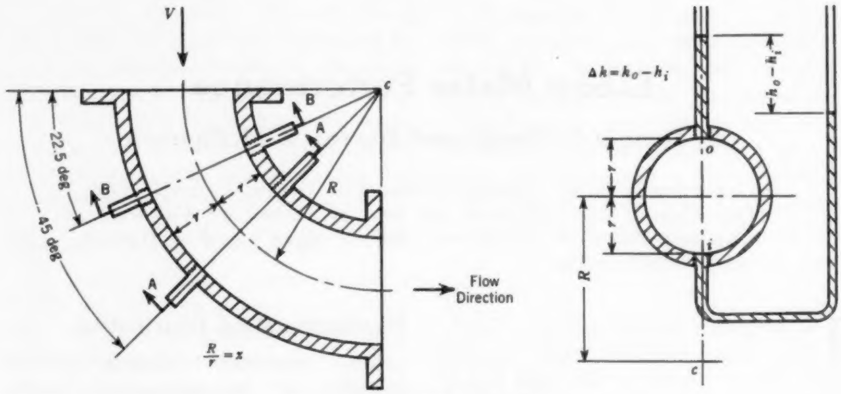

Fig. 1. Definition of Terms

The drawing defines the terms used in the section on piezometric-head distribution. At left is a longitudinal cross section through the taps; the portion at right shows Cross Sections A–A and B–B.

Sooy (*1*) made the first "meter" experiments "to show that there exists a consistent relation between the flow of water through an elbow and the difference in head between the convex and concave sides of the bend, also to show the possibilities of the use of an elbow as a measuring device." Yarnell (*2*) also demonstrated that a distinct head-discharge relationship could be attained with a given circular elbow. Lansford (*3*) conducted a broader program, with similar results, and proposed the bend coefficients, C_k, as defined by:

$$\Delta h = C_k \frac{V^2}{2g} \quad \text{(4)}$$

in which Δh is the differential head across the bend and V is the average velocity (see Fig. 1 for definitions). Lansford found good correlation of his data when he substituted the average velocity for v, the centerline radius for n, and the elbow diameter, D, for ∂n in Eq 1. If the centerline radius, R, divided by the elbow cross-section radius, r, is called x, the relation adopted by Lansford reduces to:

$$C_k = \frac{4}{x} \quad \text{(5)}$$

If Eq 3 and 4 are combined through the frictionless energy equation, the following is obtained for two-dimensional flow:

$$C_k = \frac{16x}{\left[(x^2 - 1)\left(\log_e \frac{x+1}{x-1}\right)\right]^2} \quad \text{(6)}$$

Assuming that Eq 1 can be extended to a circular section, an exact integration for frictionless flow in a circular section yields:

$$C_k = \frac{x}{[(x^2 - 1)(x - \sqrt{x^2 - 1})]^2} \quad \text{(7)}$$

Available Performance Data

The usual location of piezometer taps is at the midplane of the bend, at

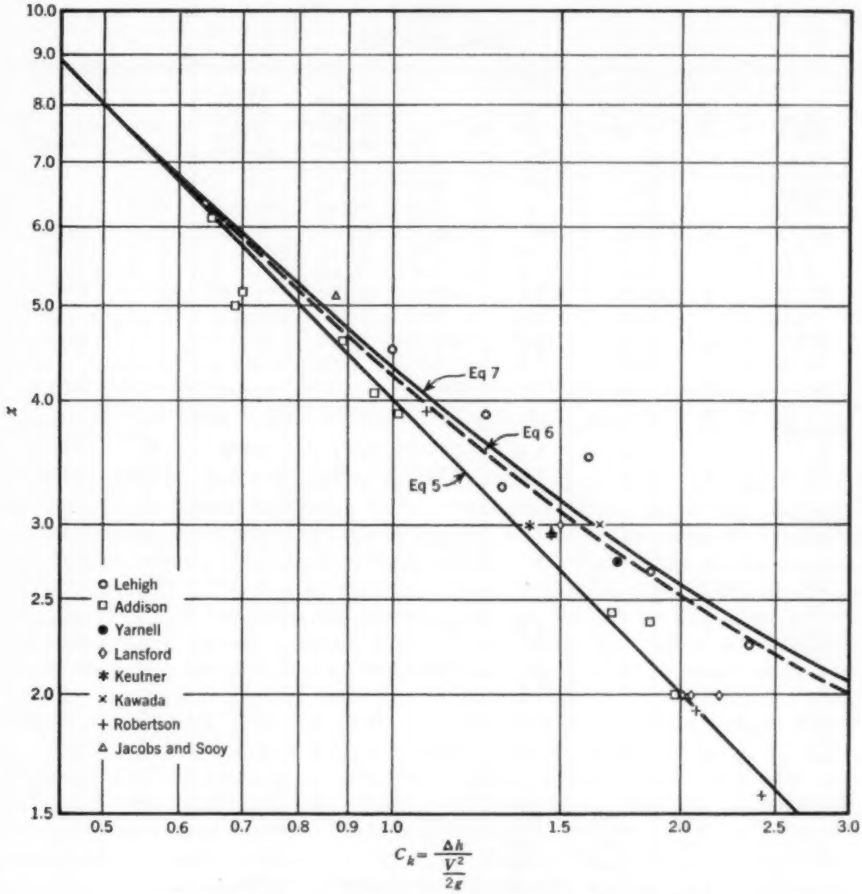

Fig. 2. Elbow Meter Flow Characteristics (45-deg Taps)

The wide scatter of available data is evident. $x = \frac{R}{r}$. *Elbows are 90 deg.*

45 deg. The larger share of reference data cited is for this arrangement. A compilation of reconstructed data is given in Table 1 and plotted in Fig. 2. Whereas Lansford deliberately used long lengths of pipe before and after the test elbows, Addison (*4*) made no attempt to avoid disturbances on either side of the elbow, but ran tests on all the miscellaneous elbows installed in his laboratory. Elbow Q (Table 1) was preceded immediately by a gate valve above which was a "helix" water meter. Elbow P was connected directly to the discharge flange of a centrifugal pump and followed immediately by a valve. Elbow L was attached to the wall of a flat-sided tank, the supply for this elbow. The remaining elbows were preceded and followed by an arbitrary length of straight pipe.

TABLE 1

Elbow Meter Data

Elbows Tested*	D *in.*	r *in.*	R *in.*	x	Approach Length of Pipe *diameters*	Downstream Length of Pipe *diameters*	C_k 22.5°	C_k 45°
Lansford								
A	4	2	6	3.0	25.5 384 450	20§		1.50
B	8	4	8	2.0	16 218	7§		2.00
C	10	5	10	2.0	0 22	22 0 14		2.05
D	12	6	12	2.0	8	?		2.20
Yarnell								
E	6	3	8.25	2.75	>30§	>30§	1.78	1.72
F	6	3	8.25‡	2.75‡	5§	0	1.78‖	2.20‡‡
Lehigh								
1	8	4	9	2.25	22	7	2.29	2.35
2a	6	3	8	2.67	18	10	1.81	1.86
2b					9	2	1.85	1.81
2c					4	0	1.85	1.95
3a	4	2	6.5	3.25	12	60	1.27	1.30
3b					20	24	1.23	1.22
4	4	2	7	3.50	20	24	1.19	1.58
5a	6	3	11.5	3.83	18	10	1.07	1.25
5b					8	10	1.07	1.24
5c					0	9	1.07	1.16
6	4	2	9	4.50	20	24	0.93	1.00
Robertson								
4–1–0.8	4.01	2.00	3.10	1.56				2.40
4–2–0.8	4.03	2.01	3.20	1.60				2.45
4–3–1.0	4.01	2.00	3.90	1.94				2.07
4–4–1.0	4.02	2.01	3.85	1.92	450	25.5		2.02
4–5–1.5	4.01	2.00	5.90	2.94	25.5	?		1.44
4–6–1.5	3.99	2.00	5.90	2.96				1.47
4–7–2.0	4.01	2.00	7.80	3.90				1.09
4–8–2.0	4.01	2.00	7.80	3.90				1.07
Keutner	25†	12.5†	37.5†	3.00	12	12	1.43#	1.39#
Kawada	8	4	12	3.00	20	25	1.55**	1.63**
Jacobs & Sooy								
G	6	3.04	8.92	2.93	12	4		1.46
H	4	1.92	9.90	5.15	19	6	0.81††	0.87

* Material: Lansford: cast iron, standard. Yarnell: E—celluloid, standard; F—cast iron, standard. Lehigh: 1–3—cast iron standard; 4—cast iron, heavy; 5–6—cast iron, long radius. Robertson: cast iron, special. Keutner: cast iron. Kawada: cast iron. Jacobs and Sooy: cast-iron bell-and-spigot joint.
† Centimeters. ‡ Presumed. § Estimated from photographs.
‖ 21.5 deg. # Interpolated; only one rate of flow.
** Only one rate of flow. †† 30 deg. ‡‡ 38.5 deg.

TABLE 1—*Elbow Meter Data* (*contd.*)

Elbows Tested*	D *in.*	r *in.*	R *in.*	x	Approach Length of Pipe *diameters*	Down-stream Length of Pipe *diameters*	C_k 22.5°	C_k 45°
Addison								
J	4	5.23†	24.00†	4.58	89.0	6.7		0.889
K	4	5.09†	31.00†	6.10	5.6	5.0		0.647
L	10	12.50†	29.60†	2.37	0	4.2		1.86
M	6	7.62†	39.10†	5.14	3.94	8.65		0.697
N	8	10.06†	38.70†	3.85	10	0		1.02
P	8	9.98†	24.1†	2.41	0	0		1.70
Q	3	3.88†	19.35†	4.99	0	2.68		0.685
S1	4	4.94†	9.80†	1.99	35.5	10.1		1.96
S2	4	4.91†	20.2†	4.11	35.5	10.1		0.960
S3	4	4.92†	30.2†	6.13	35.5	10.1		0.657

* Material: Addison: J—galvanized wrought iron, 3 years old; K—black wrought iron, new; L—cast iron, 9 years old; M—cast iron; N–P—cast iron, 12 years old; Q—black wrought iron, 8 years old; S1–S3—cast iron, special.
† Centimeters.

Also given in Table 1 are the correlated data from Robertson (*5*), Keutner (*6*), and Kawada (*7*), as well as results recently obtained at Lehigh University (*8*). The type of material and the length of upstream and downstream straight piping, in terms of elbow diameters, are also shown. Most of the data were released contemporaneously, between 1936 and 1938.

A study of Table 1 and Fig. 2 will indicate little consistency of data for identical long approach and downstream piping, and relatively little effect from a drastic reduction in these lengths for a given elbow. From the wide scatter of the available data for 45-deg taps, it is evident that an accurate prediction of the discharge-head relationship is not possible.

While analyzing the predictability of incipient cavitation in bends of hydraulic structures (*9*), it was noted that the special data presented by Yarnell (*2*) for piezometer taps located 22.5 deg from the point of curvature of the celluloid bend gave values of C_k closer to Eq 6 or 7 than 45-deg taps did. (The 22.5-deg station was also the plane of the largest values of h_i and h_o.)

Flow in a bend is modified by boundary shear, secondary currents, and an inclination toward separation (*10*), all tending to increase as the flow progresses around the bend. If taps are located at 22.5 deg and the flow further approaches potential motion (Eq 6 or 7), a more stable and predictable value of C_k should result; the effect of piping arrangement should be even less than that found by Addison for 45-deg taps. The results with 22.5-deg taps at Lehigh, together with those of other observers, are presented in Fig. 3. The Lehigh tests were conducted with a variety of arbitrary approach and downstream lengths of straight pipe to determine the relative influence of piping arrangement on the stability of C_k. Although the tests were not sufficiently exhaustive to warrant sweeping conclusions, there is evidence of a more consistent trend in the variation of C_k with x and a reasonable independence of the effect of upstream and downstream piping.

Consistency of data at both 22.5-deg and 45-deg tap locations is exemplified in the sample calibration curves of Fig. 4. The lowest Reynolds numbers reached in the Lehigh tests were: for

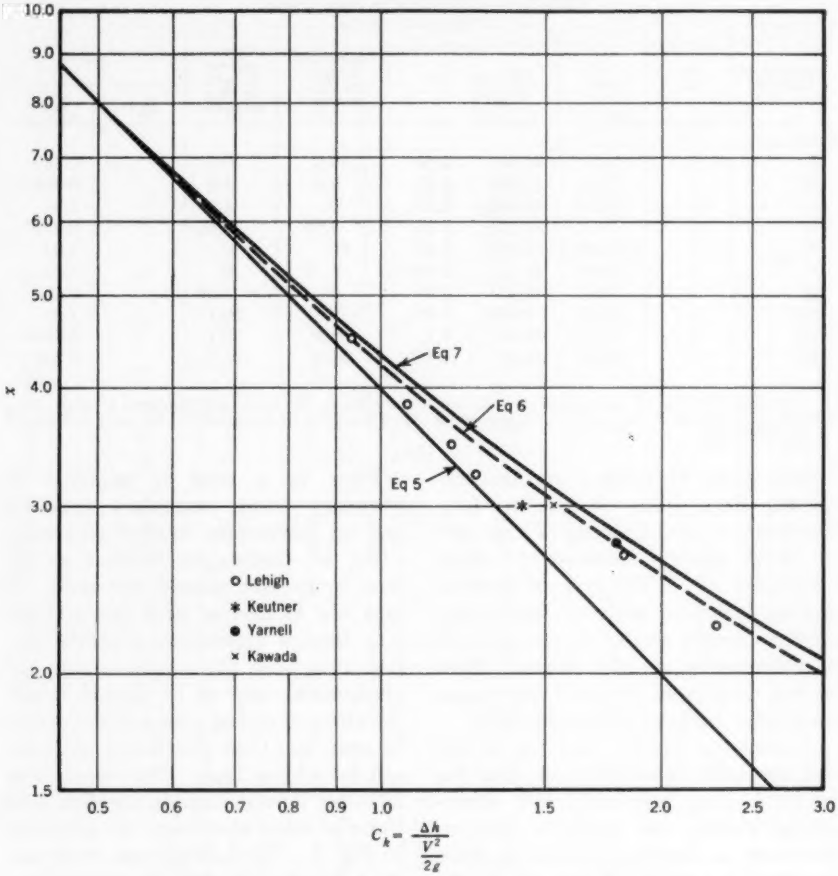

Fig. 3. Elbow Meter Flow Characteristics (22.5-deg Taps)

A relatively consistent trend in the variations of C_k *with* x *is apparent.* $x = \frac{R}{r}$. *Elbows are 90 deg.*

8-in. diameter, 10^5; 6-in., 1.5×10^5; and 4-in., 1.8×10^5. Although Lansford (*3*) found a change of C_k in some instances at Reynolds numbers above these values, no apparently similar effect was noted in the Lehigh tests.

Test Procedures

Commercial cast-iron, flanged, 90-deg elbows were used for all the tests. Six elbows were chosen to provide a wide range of x values. Each elbow was tapped at the upstream 22.5-deg and at the 45-deg cross section.

All the tap holes were $\frac{1}{8}$ in. in diameter. These holes led to fittings in the outside wall of the elbow which were connected to a differential manometer. If the elbow wall was thin, the pipe fitting was placed all the way

through the elbow, the end was filled with lead, and a $\frac{1}{8}$-in. hole was drilled through the lead. On the inside of the elbow, all projections at the taps were worn down to the wall level. To insure a uniform condition in all the elbows, an area of 1–2 sq in. was smoothed off around each tap hole. (Lansford and Robertson used $\frac{1}{4}$-in. tap holes.) Differential-head manometers were used to measure Δh. A water manometer was used to measure a range of Δh from 0.2 to 3.5 ft of water, and a mercury manometer was employed for heads above 3.5 ft.

For all the studies made, the regulating valve was placed downstream from the elbow. In the initial investigation, each test elbow was preceded by at least eighteen and followed by at least seven diameters of straight pipe. After the basic flow experiments had been completed, others were run with variable upstream and downstream tangent lengths, to investigate the specific effects of change of piping arrangement on C_k values.

Using a calibrated venturi meter, each elbow meter was calibrated twice for every piping arrangement, once with 22.5-deg and once with 45-deg taps. Each calibration required approximately 20 runs. A total of about 440 runs was made for this investigation. Most of the reference elbow C_k values represent ten or more rates of flow.

Conclusions

The results obtained in this study lead to the following conclusions regarding the use of pipe elbows as metering devices:

1. With the usual 45-deg taps:

a. There is a large discrepancy in the results of different investigators, regardless of the piping arrangement used.

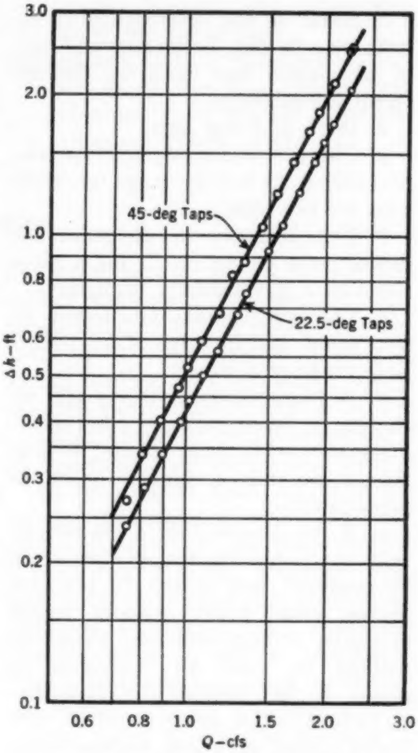

Fig. 4. Calibration Curves for Elbow 5a (Lehigh)

45-deg taps:	*22.5-deg taps:*
$Q = 1.41\sqrt{\Delta h}$	$Q = 1.52\sqrt{\Delta h}$
$C_k = 1.25$	$C_k = 1.07$

$$x = \frac{R}{r} = \frac{11.5}{3} = 3.83$$

b. The effect upon C_k of changing pipe lengths, either approach or downstream or both, is minor compared with the wide range of values of C_k obtained by different investigators, but the effect is too great to be ignored.

c. The claim of 90 per cent accuracy (discharge) for Eq 5 does not appear to be valid.

d. There is no consistent relation between C_k and any of the equations for potential flow, in terms of x.

e. Some of the discrepancy in results may be due to the size and type of piezometer taps used by the different investigators.

2. With 22.5-deg taps:

a. There is reasonably good correlation within the narrow range for which data are available.

b. The influence of upstream and downstream piping on C_k for a given value of x is apparently negligible.

c. The experimental data follow Eq 6 in trend, and in value of C_k, over a wide range of x values.

d. A continuation of this study, including an investigation of other measuring stations between 20 and 40 deg, should provide a higher order of predictability.

e. If the data of Fig. 3 are universally applicable, the rate of flow could be predicted well within 10 per cent of the actual figure, without regard to piping arrangement and, therefore, without the need for calibration in place. In fact, because the piping has so little effect, a meter could be calibrated almost anywhere, without using or duplicating the final installation.

3. Regardless of whether 45-deg or 22.5-deg taps are used, an elbow accurately calibrated in place will indicate discharge rates with a probable error not exceeding about 2–3 per cent, assuming a consistent range and accuracy for the manometer used.

Special Application

Addison (*4*) has suggested that an elbow near a centrifugal pump be tapped as a meter. He states that, regardless of the head-discharge relationship which obtains, a given manometer deflection "would, in any event, give quite a reliable guidance concerning the relative flow in the pipe. Thus, a pump user who had made a single differential-head reading on a bend in the delivery pipe could tell at any later date whether or not the pump was holding its output."

Acknowledgment

The Lehigh University tests were conducted in the hydraulic laboratory of, and were sponsored by, the Dept. of Civil Engineering and Mechanics, Fritz Engineering Lab. W. J. Eney is department head and Fritz Lab. director. The C.D.C. Control Service Co. of Hatboro, Pa., provided the test elbows. Valuable assistance was given by H. S. Strausser and employees of the Fritz Engineering Lab.

Most of the reconstruction and correlation of data appeared first in a previous article (*9*). The test program followed was outlined in a paper by Taylor (*8*).

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Discussion

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The use of elbows for metering purposes in water works presents several advantages that would be reason enough for the wide acceptance of such devices if it becomes possible to anticipate their calibration. Many civil and most sanitary engineers have probably been attracted to the idea, on observing piping layouts with numerous bends in appropriate locations for flow measurement.

One advantage would be the presence of a meter without the introduction of additional head loss, such as would be caused by orifice plates or other popular metering devices in pipelines. An elbow would not produce this effect, as it is already a part of the piping network.

A second advantage of the elbow meter would be its low cost. The only expense would be that of drilling and tapping for manometer connections, plus the cost of the manometer or recorder and connecting tubing and appurtenances. For the engineer whose practice involves small communities, the task of providing adequate metering facilities would become easier. Funds are generally limited, and, unfortunate though it may be, money expended for metering purposes is often looked upon with disfavor by the village board. Thus, metering facilities are frequently among the first items to be stricken when the required minimum design is estimated to cost more than the funds available.

As the authors point out, it would be very convenient to be able to predict the calibration of the elbow meter. The writer believes, however, that, until this can be done, the elbow meter will not be generally used, as calibration in place is seldom practicable. The authors' work is a step toward the achievement of this requirement.

The writer agrees that the data on the dependability of 22.5-deg taps are scanty. Additional data from other investigators would be of interest.

One last observation seems appropriate. The degree of accuracy necessary for the metering task at hand would be an important consideration in predicting the calibration of an elbow meter. It appears that precision metering resulting from theoretical calibration would be unlikely, in view of factory tolerances involved in the manufacture of cast-iron pipe, as well as upstream and downstream conditions.

Radioactive Fallout in Cincinnati Area

By J. S. Nader, A. S. Goldin, and L. R. Setter

A paper presented on Sep. 22, 1954, at the Kentucky-Tennessee Section Meeting, Nashville, Tenn., by J. S. Nader, Physicist; A. S. Goldin, Chemist; and L. R. Setter, Asst. Chief, Physics & Chemistry Section, Research & Development Branch; all from R. A. Taft San. Eng. Center, Cincinnati, Ohio.

A STUDY of the radioactivity of precipitation in the Cincinnati, Ohio, area was made for 12 months beginning March 1953. Seven samples of precipitation between Mar. 3 and Mar. 18 were tested to obtain the background level in rainfall. On Mar. 19, 2 days after the first Atomic Energy Commission (AEC) nuclear-weapons test of the spring series, a sharp rise in the beta activity of the rain occurred. The radioactivity of subsequent rains during the test period was usually of greater intensity and varied widely. Following the AEC tests the activity of the rain decreased to levels near that of background. All the activity measured was far below the intensity considered hazardous. The more pertinent findings of this study are presented in this paper.

The precipitation, falling on a tray 0.54 sq m in area, was collected at 1014 Broadway in Cincinnati until October, when the sampler was moved to the roof of the Robert A. Taft Sanitary Engineering Center, at 4676 Columbia Parkway in Cincinnati. At intervals, between infrequent rains, the collecting tray was flushed with water to remove fallen soot.

Procedure

Rain accumulations were usually taken from the sampler between 8 and 9 AM on weekdays, and weekend rainfall was allowed to accumulate until Monday morning. Several samples of snow were collected from relatively clean surfaces. The volume of rainfall was measured, and the US Weather Bureau reports were consulted for an estimation of the average precipitation in the Cincinnati area. On days when several samples were collected, rainfall was prorated on the basis of sample collections.

An aliquot of rain was passed through a membrane filter for an assay of radioactivity associated with suspended solids, and the filtrate was evaporated, dried, and counted for an assay of the "soluble" radioactivity (*1*). The suspended solids and dissolved solids were determined, in order to estimate the self-absorption correction. This correction factor was calculated from measurements of samples of various thickness prepared from an active rain.

The net counting rate was corrected for geometry, back scatter, and self-absorption and was reported in micromicrocuries ($\mu\mu$c) per milliliter. Generally, the suspended-solids radioactivity was counted on the day of sample collection, and the filtrate or soluble activity within 24 hr. The sum of these two values, uncorrected for decay, was reported as total beta radio-

activity. Most of the samples with an appreciable activity were counted periodically for several weeks, or until decay had reduced the count to approximately twice background.

Results

Some of the results of these tests are summarized in Table 1. The rains were arbitrarily grouped into nineteen sample series—one (No. 0) covering the period before the weapons tests, eleven (No. 1–11) covering the period following each of the eleven bomb bursts, and seven (No. 12–18) covering periods of ½–2 months each, subsequent to the bomb tests. The snow and rain samples prior to Mar. 18, 1953, had a background radioactivity level of 0.03–0.08 $\mu\mu c$ per milliliter, of which usually 50–100 per cent was soluble.

During the weapons test period the radioactivity of the rain increased many fold. A maximum activity of 319 $\mu\mu c$ per milliliter was observed in a small rain of 0.02 in. on Apr. 29. This rain had a decay rate comparable to that of a 4-day-old fission product. When extrapolated to age 3 days, the activity may be estimated to be 500 $\mu\mu c$ (0.0005 μc) per milliliter. Thirty per cent of the total activity of this sample was soluble. According to the AEC (*2*), "Safe concentrations of a mixture of fission products in drinking water depend upon the composition of the mixture and upon the period of time

TABLE 1

Radioactivity in Rain Water

Sample Series	Date of Bomb Burst 1953	Avg Age of Fission Product *days*	Total Rain *in.*	Radioactivity			Residual Activity	
				Weighted Avg *μμc/ml*	Total *mc*/sq mi*	Soluble *per cent*	Jun. 10, 1953 *mc*/sq mi*	Dec. 10, 1953 *mc*/sq mi*
0			2.49	0.05	8.3	60		
1	3/17	4	0.05	2.13	7.0	31	0.18	0.04
2	3/24	7	0.18	2.90	34.4	5	1.9	0.45
3	3/31	4	0.68	2.47	110.	23	3.5	0.74
4	4/6	6.5	0.58	2.56	98.	20	6.1	1.22
5	4/11	6	1.31	2.98	257.	12	16.2	3.01
6	4/18	5	0.30	1.56	30.8	17	1.8	0.30
7	4/25	6	0.92	22.4	1,360.	17	118.	16.9
8	5/8	5.5	1.56	1.78	183.	26	21.	2.22
9	5/19	3.5	1.94	80.6	10,300	5	1,135	76.6
10	5/25	13	1.32	2.71	235	23	183	8.84
11	6/4	6	0.74	1.85	900	27	900	14.75
12		18	0.89	1.67	98	25		6.88
13		37	3.97	0.22	56.7	40		12.70
14		67	1.05	0.105	7.3	34		
15		150	1.69	0.085	9.3	79		
16		195	1.36	0.08	7.27	82		
17		224	1.51	0.03	2.79	80		
18		256	0.04	0.08	0.22	40		
Total					13,515.†		2,386.	145.

* Millicuries.
† Excluding Sample Series 0, 12–18.

over which the water is used. It is estimated that water containing total fission product activity amounting to 0.005 μc per milliliter 3 days after the fission products were formed could be used safely for any period of time." The maximum fallout of radioactivity from a single rain occurred on May 22, when 1.55 in. of rain containing 85.7 $\mu\mu$c per milliliter fell, resulting in a fallout of 8.75 curies per square mile.

By Aug. 4, or 2 months after the last AEC test, some rains indicated a background level comparable to that before the weapons tests, but six of the twelve rains tested in August, September, and November and eight of the twenty rains tested in December, January, and February had a radioactivity between two and three times the background level.

A comparison of the decay curves of rains with the theoretical decay of fission products (*3*) indicates that the activity of a rain may be due to a bomb burst two or three steps earlier in the sequence than the sample series in question. Typical examples are given in Table 2, in which the half-life of a specific rain sample of maximum activity in each of eleven sample series is compared with the calculated half-lives for bomb fission products. The half-lives of rain and bomb material were measured from the "initial decay date." The activity in the rains of Sample Series 1–3, 5, 7, and 9 appears to be the result of the bomb burst immediately preceding the rains (see italicized values), whereas the activity in the remaining rains appears to be due to earlier bursts. For example, the rain in Sample Series 4, on Apr. 13, seems to be due to Bomb No. 2, on Mar. 24. Activity from products formed in the sixth bomb burst, on Apr. 18, apparently was not observed in rains at Cincinnati.

For each sample series, the weighted average radioactivity of the rainfall, the weighted average percentage of soluble activity, and the total radioactivity which fell per square mile were calculated. Figure 1 shows graphically that, from an average background level of 50 $\mu\mu$c per liter (log

TABLE 2

Half-Life of Rain Samples of Maximum Activity Between Bomb Bursts

Sample Series	Sample Date 1953	Initial Decay Date 1953	Rain Sample Half-Life *days*	Half-Life (*days*) for Fission Product Formed on										
				3/17	3/24	3/31	4/6	4/11	4/18	4/25	5/8	5/19	5/25	6/4
				Bomb Burst No.										
				1	2	3	4	5	6	7	8	9	10	11
1	3/19	3/20	3.2	*2.3*										
2	3/31	4/1	4.5	11.3	*6.2*									
3	4/6	4/6	5.0		9.7	*4.7*								
4	4/13	4/13	14.		*15.*	9.7	5.5							
5	4/16	4/17	3.7				8.3	*4.7*						
6	4/19*	4/20	9.0				*10.5*	*7.0*	1.5					
7	4/29	4/29	3.4						8.3	*3.3*				
8	5/11*	5/11	8.5							*12.0*	*2.3*			
9	5/22	5/22	2.0								10.5	*2.3*		
10	6/7	6/8	17.								25.3	*15.0*	10.5	3.3
11	6/10	6/10	10.										*12.0*	*4.7*

* Collection made at 4:00–4:30 PM.

1.7) of rain in Sample Series 0, the activity rose to a maximum of 80,600 $\mu\mu c$ per liter (log 4.9) for a sample series. Following the last bomb burst on Jun. 4, the average activity in the rain decreased to within the range 30–80 $\mu\mu c$ per liter. The soluble activity in the rain, which was 60 per cent of the total activity before the spring bomb tests, fell to less than 30 per cent during the tests. The soluble activity increased to about 80 per cent after the test series.

Table 1 gives a rough estimate of the average age, in days, of the fission product in each sample series. From this age, and the theoretical decay curve (*3*), an estimate was made of the radioactivity per square mile that would be left on Jun. 10 and Dec. 10, 1953. A summation of the fallout per square mile for the period Mar. 19–

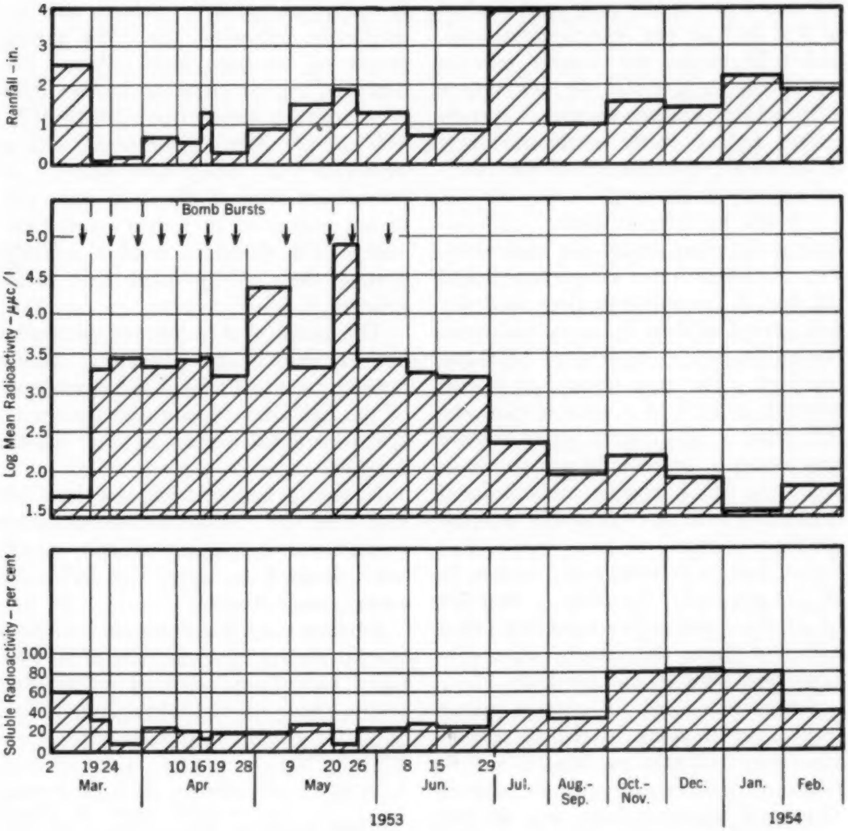

Fig. 1. Radioactivity Fallout in Cincinnati Area

The maximum radioactivity for the period was 80,600 $\mu\mu c$ per liter (log 4.9).

Jun. 10 (Series 1–11) shows that, of the 13.5 curies of activity which fell per square mile, the residual on Jun. 10 would be 2.4 curies. On Dec. 10 the residual activity from the rains that fell from Mar. 19 to Jul. 25 would be 0.15 curies per square mile. In metric units, 2.4 curies per square mile is equivalent to 9×10^{-5} μc per square centimeter, and 0.15 curies per square mile is equivalent to 6×10^{-6} μc per square centimeter. Factors of runoff, percolation, and so forth would obviously influence the distribution of the residual activity in the area.

A few samples of surface and cistern water were tested for radioactivity. A cistern water sample was tested on Apr. 7, immediately after an 8-day wet period of 0.86 in. of rainfall containing an average activity of 2,500 $\mu\mu$c per liter. The roof water had seeped through a wall of cinder blocks into the cistern. The cistern water activity was found to be only 29 $\mu\mu$c per liter. On Apr. 15, following an additional 0.46 in. of rain of comparable activity, another, similar cistern water was tested, and its activity was found to be 20 $\mu\mu$c per liter. On May 1, after 0.3 in. of the most active rain had fallen within 4 days, the cistern water assayed less than 10 $\mu\mu$c per liter.

Several samples of surface water from a small creek in the Cincinnati area were collected on May 5 and 6, following 0.32 in. of rain on May 5. The creek water activity was 69–163 $\mu\mu$c per liter, 41–51 per cent of which was soluble. The Cincinnati tap water during this period had an activity of less than 30 $\mu\mu$c per liter.

From these scattered tests, it appears that most of the radioactivity is readily removed from rain water by natural purification.

Summary

Precipitation at Cincinnati from March 1953 to March 1954 was sampled and tested for suspended and soluble beta radioactivity. During and immediately following the 1953 spring series of weapons tests (Mar. 19–Jun. 29) the radioactivity in the 10.86 in. of rainfall varied from 280 to 319,000 $\mu\mu$c per liter, as compared with a prebomb test background activity of 50 $\mu\mu$c per liter. Only three rains out of ten examined in January and February 1954 showed a level of activity greater than the prebomb test background.

The activity of rains can generally be attributed to particular bomb bursts, on the basis of a comparison of the half-lives of rain activities with the theoretical decay of the fission product.

It was estimated that, on Jun. 10 and Dec. 10, 1953, the accumulated rainfall activity per square mile would have decayed to about 2.4 and 0.15 curies, respectively.

Surface and cistern waters collected after rains having an activity of 50–500 times background showed an activity within three times background.

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Measurement of Radioactive Fallout in Reservoirs

By E. J. Kilcawley, H. M. Clark, H. L. Ehrlich, W. J. Kelleher, H. E. Schultz, and N. L. Krascella

A paper presented on Sep. 9, 1954, at the New York Section Meeting, Montauk, N.Y., by E. J. Kilcawley, Head, Div. of Soil Mechanics & San. Eng.; H. M. Clark, Prof. of Physical & Nuclear Chemistry; H. L. Ehrlich, Asst. Prof. of Biology; W. J. Kelleher, Asst. Prof. of San. Eng.; H. E. Schultz, Teaching Asst.; and N. L. Krascella, Research Asst.; all from Rensselaer Polytechnic Inst., Troy, N.Y.

EARLY in the evening of Apr. 26, 1953, the Troy, N.Y., area experienced an exceptionally violent electrical storm. One of the worst flash storms in recent years, it was characterized by high winds, hail, and torrential rains. This storm was unique in that it brought with it levels of radiation which, though certainly nonhazardous, were higher than those normally found in the area. The presence of this radiation was detected on the following day, approximately 48 hr after the Atomic Energy Commission (AEC) had detonated its seventh nuclear device in the spring test series at the Nevada Proving Grounds. It was observed that the background rate for the Geiger-Muller counters in the radiochemistry laboratory at Rensselaer Polytechnic Institute in Troy was unusually high. The counter located nearest the outside wall of the building was found to be registering at more than three times the normal rate of about 30 counts per minute (cpm). The rise in background rate decreased with increasing distance from the outside wall. The beta and gamma radiation outside the building was measurable with portable radiation survey meters.

These findings were supplemented by various types of radioactivity measurements upon such objects as concrete pavement, paper, cloth, asphalt shingles, and leaves of burdock and dandelion plants exposed to the rainout. Samples of rain water were obtained from surface puddles. Four samples of water were taken from Tomhannock Reservoir and samples of tap water (supplied from another reservoir) were also processed and counted. The ground was measured with a portable Geiger-Muller type of survey meter and a "Zeus" * ionization chamber survey meter. At various selected points on or near the campus, ground radiations measured 1 in. above the surface were found to vary from an average of 0.4 milliroentgens per hour (mr) for gamma radiation 1.1 days after arrival to a high value of 6 mr per hour (120 for beta plus gamma) 2.1 days after arrival.

The activity per square foot was found to be comparable with that reported by Eisenbud and Harley (*1*)

* A product of Rouland Corp., Chicago.

for fallout from the 1952 tests as settled dust at stations in Utah and Nevada in the 200–500-mile band around the test site. The Tomhannock Reservoir water showed an activity of 0.8 micromicrocurie ($\mu\mu c$) per milliliter 1.8 days after arrival and tap water showed 2.63 $\mu\mu c$ per milliliter 1.1 days after arrival. By comparison, the maximum activity observed in the surface waters of Massachusetts following the 1952 nuclear-weapons tests was 0.14 $\mu\mu c$ per milliliter (*2*).

Autoradiographs were made of sections of plant leaves, paper, cloth, and wood by exposure for 24 hr to an Eastman "No Screen Medical X-ray" film.* Porous materials, like paper, and others having a rough surface, like wood, asphalt shingles, and plant leaves, exhibited the greatest activity. Details of the measurements and observations made during the period between the occurrence of the rainout and the initiation of the study described in this article have been reported elsewhere (*3*).

Information concerning the rainout was made available to state and county health departments and to the AEC. With the encouragement and support of the AEC, a study of the distribution and fate of the fission products deposited in the water supply reservoirs of the Troy area was conducted during the summer of 1953.

Troy Area Water Supply

Both Troy and Albany, N.Y., have surface supplies. The former depends on long-term storage and chlorination for quality control. The supply of Albany is treated by modern rapid sand filtration. The Schenectady, N.Y., supply is obtained from ground water. According to the 1950 census, the population of these cities was, respectively, 72,311, 134,995, and 114,870; the average consumption is 354, 188, and 190 gpcd, respectively.

Troy has three sources of supply—the Tomhannock, Grafton, and Brunswick-Vanderheyden reservoirs—located 6.5 miles northeast, 16 miles east, and 5 miles northeast of the city, with drainage areas of 67, 17, and 1.5 sq miles, respectively. The drainage area of Tomhannock Reservoir is 45 per cent wooded. The surface area of the reservoir is 165 acres, its maximum depth is 45 ft, its average depth is 22 ft, and its capacity is 13.7 bil gal. The Grafton supply consists of six natural ponds and two impounding reservoirs. The drainage area of approximately 17 sq miles is 81 per cent wooded. The Brunswick-Vanderheyden (Troy Reservoir) supply has a drainage area of only 1.5 sq miles, which is principally farmland. Its storage capacity is 153 mil gal. This reservoir also serves as a storage facility for a portion of the Grafton supply.

The Albany supply is obtained from impounding reservoirs in the Helderberg-Catskill mountain region, located about 20 miles southwest of the city. The interconnected reservoirs have a combined capacity of 12.8 bil gal, a flooded area of 1,705 acres, and a drainage area of 48.9 sq miles, approximately 28 per cent wooded. Basic Reservoir stores 716 mil gal and has a maximum depth of 17 ft. Water flows from it to Alcove Reservoir, which stores 12.1 bil gal and has a maximum depth of 74 ft and an average depth of 25 ft. All of the supply is drawn from Alcove and is conducted to a filtration plant at Fuera-Bush,

* A product of Eastman Kodak Co., Rochester, N.Y.

approximately halfway to the city, through a 48-in. cast-iron pipeline. After filtration, the water flows through a continuation of the 48-in. conduit to the 210-mil gal Loudonville Distribution Reservoir, near the city limits.

The ground water pumping station for Schenectady draws from nine 24-in. gravel-packed wells, varying in depth from 58 to 70 ft, and one 20-in. well, 56 ft deep. The station is located about 2.5 miles from the city and has a total capacity of 40 mgd. Water is pumped directly to the distribution system. A covered concrete equalizing reservoir of 22.1-mil gal capacity floats on the system.

Method of Study

In order to obtain the maximum amount of useful information on radioactivity in these reservoirs, it was decided to determine the level of activity over a period for samples of rain, stream, reservoir, and treatment plant waters. To learn the distribution of radioactivity, samples of dissolved and suspended solids, algae, rock scrapings, higher plants, and bottom soil were studied. (Measurements in no place yielded levels approaching the maximum amount of radioactivity in drinking water considered permissible by the AEC.)

Regularly scheduled sampling was begun on May 15 and the study continued through Aug. 31, 1953. During this period 62 samples of rain water, 192 samples of reservoir water, 57 samples from various points in the Albany treatment plant, and 37 samples of algae bloom, rock scrapings, higher plants, and bottom soil from the reservoirs were collected. From May 18 to May 23, samples of reservoir water were collected daily; from May 25 to Jun. 12, three times a week; and from Jun. 15 to Jul. 14, once a week. During the period May 24–Jul. 5, five samples were collected from the Schenectady ground water supply.

Bceause the radioactivity as of Jul. 14 was greatly reduced, regular sampling of the reservoirs was stopped. The relatively low activity of many of the samples and the short time available made it impossible to obtain all the desired data.

Radioactivity Measurements

Both beta ray and alpha particle measurements were made. Three beta counters equipped with thin mica window Geiger tubes were used. The three counters were intercalibrated at various times with the more active fission product samples collected, and, in addition, radium (Ra E) and uranium oxide (U_3O_8) standards were employed to check the overall counting efficiency or yield for each shelf position used.

With 2-in. lead shielding, the background counting rate was about 25 cpm. Background measurements were made during each day, but not routinely before and after each sampling. Counting periods averaged 20 min. Beta ray absorption measurements were made with aluminum absorbers. In general, the samples were not sufficiently radioactive to permit measurement of gamma ray intensity through very thick absorbers. Two experimental methods were used to estimate the self-absorption correction factors for thick solid samples: the external absorber method and the method of constant specific activity, using samples of alum sludge collected from

the sedimentation tank at the Albany treatment plant. The measurements showed that self-absorption coefficients between 0.01 and 0.02 sq cm per milligram were to be expected during the period of the investigation. The uncertainty was due in part to the very low counting rate of many of the sources. Because this condition also leads to significant counting errors in the measurement of the activities of the sources, however, and because the self-absorption coefficient is small, the importance of determining this factor precisely was lessened.

All alpha measurements were made with a proportional counter. The source chamber of this instrument was found to have a geometry of 50 per cent when calibrated with an alpha standard consisting of a thin deposit of uranium oxide on a nickel disk. The alpha background rate was found to be 4 cpm. Counting periods were usually 1 or 2 hr for background and for each sample. No attempt was made to correct for self-absorption or to obtain very precise measurements for samples with alpha activity very close to background. The results obtained, therefore, are best regarded as being in the nature of a semiqualitative supplement to the beta measurements.

More than 2,500 radioactivity measurements were made and most of the samples were low in activity.

Rain Water Samples

Rain water sampling stations were established on the watersheds of Tomhannock and Troy reservoirs for the Troy supply and at Alcove Dam for the Albany supply. During the period May 20–Aug. 10 samples were collected in 1-gal glass bottles through a supported galvanized-iron funnel 26-in. in diameter and 18-in. high. A measured portion of each sample was evaporated to dryness in a porcelain dish over a hot plate, and the residue was transferred to a weighed, 1-in. diameter, nickel-plated steel, cupped

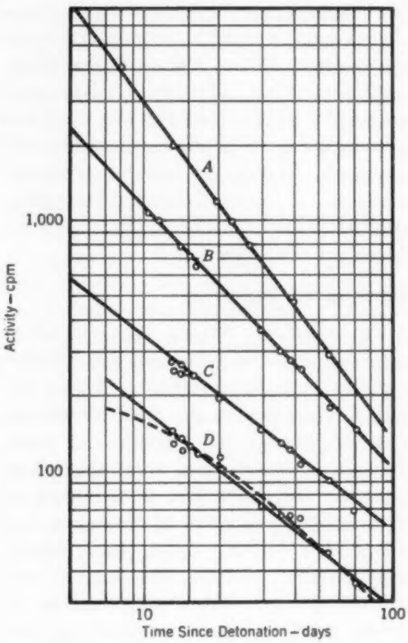

Fig. 1. Rain Water Decay Curves

Location of samples: A—*Tomhannock watershed (Bomb No. 11)*; B—*Alcove watershed (Bomb No. 9)*; C—*Troy Reservoir (Bomb No. 9)*; D—*Tomhannock watershed (Bomb No. 9)*.

planchet by the use of a polyethylene policeman. The residue was then dried under a heat lamp, weighed on an analytical balance, and counted.

For samples collected prior to Jul. 1, ten to fifteen radioactivity measurements were made on each in following

the decay. For samples collected thereafter, three to eight counts were made on each. In determining the decay curves of samples collected prior to Jun. 9, the calculations were based upon the time of explosion of Bomb No. 9 or 11, and the decay equations were used to calculate the activity at based on the time elapsed since the detonation of Bomb No. 11.

Typical decay curves for rain water are given in Fig. 1. These curves are based on the equation $A = A_0 t^{-c}$, in which A is the nuclear disintegration rate at time t after the burst of a specific bomb, and A_0 is the rate at unit

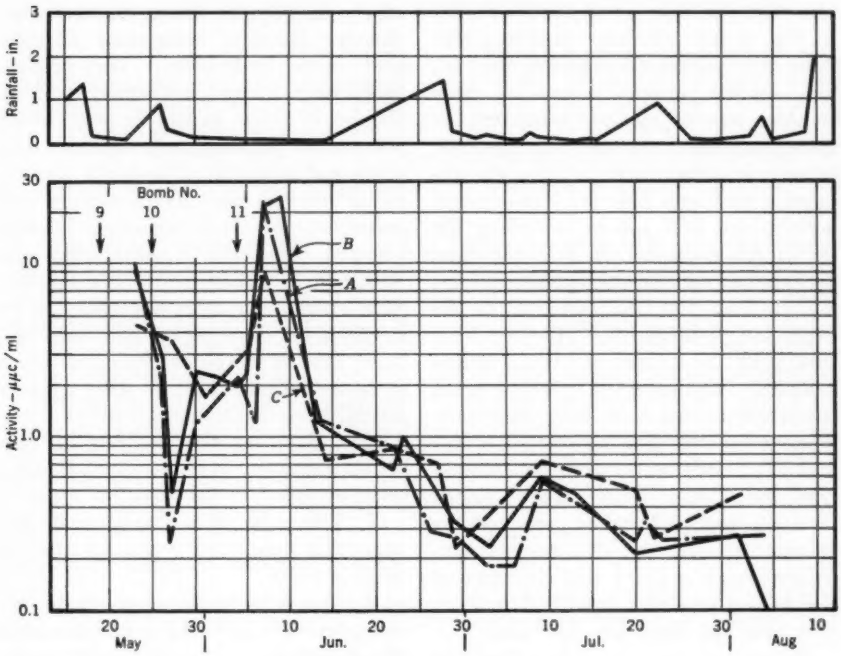

Fig. 2. Rainout Activity

A—*Tomhannock sampling station;* B—*Troy Reservoir sampling station;* C—*Alcove sampling station.* (*Rainfall data from US Weather Bureau Office at Albany airport.*)

the time of rainout. For samples collected after Jun. 9, log-log or semilog plots were extrapolated to find the activity at the time of rainout. In samples on which the number of counts was too small to obtain a suitable plot, the initial activity was arbitrarily determined by the use of the "1.2 law," time. In most instances, the plotted points do not show any detectable variation from the straight-line relationship expressed by this equation. For some samples, however, there seemed to be a deviation from the straight line; such a deviation is indicated by the broken line at Curve D in Fig. 1.

Although the equation is assumed to be correct for the fission products of a specific bomb, a mixture of fission products from several bombs would undoubtedly cause a variation from the value of 1.2 given to c when a single bomb is involved; c would then be a function of time.

The relationship between time and rain water activity at rainout is shown in Fig. 2 for the three sampling stations over the period May 22–Aug. 10. The highest activity found in these samples was 25 $\mu\mu$c per milliliter, for the sample taken on Jun. 9 at the Troy Reservoir station 5 days after the explosion of Bomb No. 11. The lowest activity was 0.07 $\mu\mu$c per milliliter, for the sample taken on Jul. 21 at the same station. It may be noted that samples collected on Jun. 7, 3 days after the explosion of Bomb No. 11, were high in activity, as compared with previous samples. The samples collected from the Tomhannock and Troy Reservoir stations on that date had slopes of 1.4 and 1.0, respectively, while the sample from the Alcove station showed slopes of 0.88 and 1.3 when referred to Bombs No. 11 and 10, respectively. Therefore, it appears that the ages of the fission products deposited in each area may not have been the same.

Figure 2 also indicates that, in evaluating the effect of rainout upon reservoir activity concentrations, both the activity and the quantity of rain must be considered. For example, the activity at the Alcove station for the samples of Jun. 7 multiplied by the inches of rain gives: $9.36 \times 0.07 = 0.65$ $\mu\mu$c-in. per milliliter, while the sample of May 27 gives: $3.59 \times 0.95 = 3.41$ $\mu\mu$c-in. per milliliter. This indicates that there was more rainout on May 27 than on Jun. 7, although the specific activity per milliliter of the rain on Jun. 7 was approximately 2.5 times as great as on May 27.

A portion of each of seven rain water samples was taken for a qualitative radiochemistry study. Measurements were made of the alpha and beta activities retained or carried by filter paper before and after concentration of the samples by barium sulfate, lanthanum fluoride, manganese dioxide, and ferric hydroxide. The precipitates were filtered and dried on 1-in. diameter filter paper circles, which were then mounted on stainless-steel disks for counting. The alpha activity of a 700-ml rain water sample collected at the Troy Reservoir station showed, following concentration and filtration, 878, 834, and 872 alpha disintegrations per hour for the activity retained on filter paper, and 878, 938, and 888 in ferric hydroxide, when measured 49, 55, and 88 days, respectively, after collection.

The data on the analysis of rain water samples led to the following conclusions:

1. The rain water contained unidentified long-lived alpha, as well as beta, activity.

2. The activity lingered in the atmosphere for at least 2 months after the explosion of the last bomb of the spring series.

3. If the rainfall was high in activity after a bomb burst, the slope of the decay curve was usually close to 1.2.

4. Variations from the straight-line theory of the decay law might be accounted for by the mixing of fission products from more than one bomb. The possible variation in the nature of fission products with the type of bomb may also have an effect upon the rate of decay.

5. It was not possible to determine the effect upon the reservoirs of the total activity deposited by a given rainfall, because of the limitations of the project.

Troy Supply Samples

Two-liter samples obtained from each of the four major streams flowing into Tomhannock Reservoir were evaporated and processed for counting in the usual manner. The data obtained showed that the activity of the stream water was low, relative to that of the rain water. The range of activity of the stream water was approximately 0.01–0.10 $\mu\mu$c per milliliter, while that of the rain water ranged from approximately 0.10 to 20. Plots of the activity of the stream water, however, showed increases which seemed to correlate with the peak activity observed in the rain water for the period Jun. 7–9, following the eleventh detonation on Jun 4.

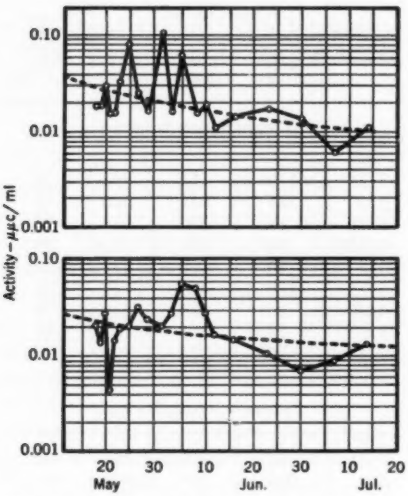

Fig. 3. Tomhannock Reservoir Activity

Top: sampling point at intake; die-out equation, $A = 0.4t^{-0.8}$. *Bottom: sampling point at Hoosick Road Bridge; die-out equation,* $A = 0.1t^{-0.5}$.

Two sampling stations were established on Tomhannock Reservoir, one at the southern end (Hoosick Road Bridge) and the other at the intake at the northern end. The sampling station on Troy Reservoir was located at the intake at its eastern end.

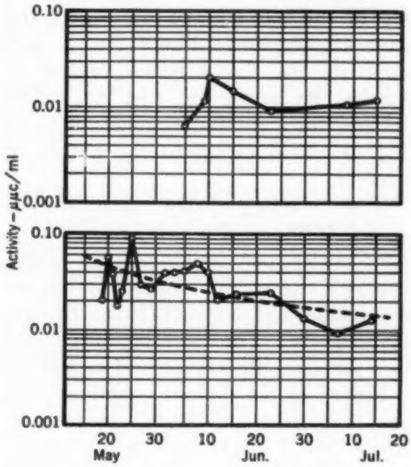

Fig. 4. Troy Reservoir and Tap Water Activity

Top: tap water. Bottom: sampling point at Troy Reservoir intake; die-out equation, $A = 1.2t^{-1.0}$.

The reservoir water samples were collected in 1-gal glass jars, and a 2-liter portion was evaporated and processed for counting in the same manner as the rain water samples. The radioactivity of the reservoir and tap water samples is shown in Fig. 3 and 4. At least two, and possibly three, peaks of activity appear in the reservoir water

during the period May 18–Jun. 10. These peaks may be associated with the last three nuclear detonations. The average activity of all stations on May 19 was 0.018 $\mu\mu c$ per milliliter. For the last samples collected (Jul. 14), the average was 0.012 $\mu\mu c$ per milliliter.

Die-out equations were computed for each sampling point by assuming a straight-line relationship between the log of the activity and the log of the time elapsed since Bomb No. 7, and applying the least-squares method to obtain the curve of best fit. The broken lines on the semilog plots in Fig. 3 and 4 represent the curves of best fit.

The resulting decay equations are $A = 0.4t^{-0.8}$ and $A = 0.1t^{-0.5}$ (in micromicrocuries per milliliter) for Tomhannock Reservoir samples taken at the intake and Hoosick Road Bridge, respectively. The corresponding equation for Troy Reservoir is $A = 1.2t^{-1.0}$.

Slopes of the die-out equations that are less than 1.2 when referred to Bomb No. 7 might have two explanations: [1] rainout from the later bombs may have increased the activity of the reservoir samples—for example, the peak points shown for reservoir samples during the period May 18–Jun. 10 may have originated with the last three tests; [2] disturbances caused by wind and temperature changes may have resulted in higher activities owing to redistribution of deposited fission products—this would have been more pronounced for shore samples.

The biological study was confined to Tomhannock Reservoir. Eighteen 5-gal samples of water, thirteen samples of rock scrapings, eleven samples of algae, four samples of higher plants, and nine samples of bottom soil were collected. The 5-gal water samples were centrifuged, and the filtrate was resuspended in tap water to a volume of 150 ml and examined qualitatively in wet mounts under the high-power dry objectives of a microscope. A 1-ml aliquot of the suspension was enumerated in a Sedgwick-Rafter (population) counting chamber under the low-power objective of the microscope, counting a total of ten fields. Diatoms were counted as a group, whereas the green algae were counted either as a group or separately as Zygnematales, Chlorococcales, *Volvox, Scenedesmus,*

TABLE 1

Activity of 5-gal Samples

Sampling Date 1953	Activity—$\mu\mu c$			Activity in Dissolved Solids *% of total*
	Suspended Solids	Dissolved Solids	Total	
Tomhannock Intake				
5/31	179	414	593	70
6/9	285	621	906	69
6/15	98	270	368	73
6/18	36	180	216	83
6/22	45	252	297	85
6/25	128	243	471	52
6/30	23	198	221	90
7/7	17	144	161	90
7/14	28	333	361	92
Hoosick Road Bridge				
5/31	68	315	383	82
6/9	905	693	1,598	43
6/15	28	147	175	84
6/18	12	226	238	95
6/22	13	153	166	92
6/25	50	207	257	81
6/30	43	118	161	73
7/7	21	173	194	89
7/14	64	165	229	72

Sphaerocystis, and *Pediastrum*. The blue-green algae were counted as *Nostoc* and *Oscillatoria*. Protozoa, nematodes, and crustaceans were noted, but no concerted effort was made to establish their numbers. The volume of inert matter was estimated at 25, 50, or 75 per cent of the total volume. After microscopic examination, the samples were recentrifuged and prepared for radioactivity counting in the usual manner. The total activity and the activity of the suspended and dissolved solids are shown in Table 1.

It may be noted that the major portion of the activity determined on a volume basis existed in the dissolved matter. This observation was confirmed by the fact that filtration through a membrane filter (0.5μ) did not produce a significant reduction in the radioactivity. In terms of specific activity per 100 mg of solids, the suspended solids were higher than the dissolved matter.

Plots of the decay rates were similar to those predicted by the 1.2 law. The relatively few variations suggested a possible difference in the composition of the radioactive matter.

The samples of rock scrapings were obtained at various points close to shore. Microscopic examination revealed the presence of algae, protozoa, nematodes, and crustaceans. Some quantitative measurements were made with a Sedgwick-Rafter counting chamber. After microscopic examination, the samples were dried, ground, and transferred to planchets for activity counting.

Because analysis of early samples indicated a correlation between radioactivity and the presence of diatoms, attempts were made to separate the diatom frustules from other living and nonliving matter by chemical treatment. The data obtained indicated that any activity associated with the diatoms was most likely due to adsorbed material. These data also showed that most of the activity of the rock scrapings resided in the inert (chiefly inorganic) matter. Plots of the data obtained showed that the die-out and decay curves approximated those predicted by the 1.2 law.

At certain times during the sampling period, algae bloom samples were collected near or at the shoreline. *Ulothrix*, *Volvox*, *Cladophora*, and *Spirogyra* were identified microscopically and processed for counting in the usual manner. No positive proof was found that the activity was concentrated in any of the algae investigated.

Samples of higher plants like *Zizaniopsis*, *Valisneria*, and *Polygonum* (from the shore of Troy Reservoir) were obtained and processed for counting in the usual manner. No positive proof was found that the activity was concentrated in any of these samples, although a slightly higher specific activity was shown by *Valisneria*.

Soil samples were collected at the shoreline, examined microscopically, ground, and processed for counting as usual. The data indicated a possible correlation between the activity of the soil and that of the higher plants. On the whole, all soil samples showed a decay rate predicted by the 1.2 law.

Albany Water Samples

The one sampling station established on Alcove Reservoir was located near the dam at the intake. Samples of water were collected at the surface, following the same schedules as for the Troy supply. These samples were

processed for counting in the usual manner. The results of the radioactivity determinations are shown in Fig. 5. It may be noted that the activity of this water is higher than that of the Troy reservoirs. This is consistent with the fact that the rainout on Apr. 26 was heavier at Albany than in the Troy area.

As in the Troy water supply reservoirs, the die-out equation was computed by assuming a straight-line relationship between the log of the activity and the log of time elapsed since the detonation of Bomb No. 7, and applying the least-squares method to obtain the curve of best fit. The broken line in Fig. 5 represents this curve, the equation of which is $A = 1.8t^{-1.1}$.

The filtration plant is the conventional rapid sand filter type. It consists of an enclosed aerator; three around-the-end mixing and flocculation basins, providing a 25-min detention; three settling basins; eight 4-mgd filter units; and a clear-water basin of 2-mil gal capacity. Alum is used for coagulation, lime is employed to maintain the proper pH for manganese removal, and the filtered water is chlorinated.

Samples of raw, aerated, settled, filtered, and backwash water and sedimentation tank sludge were taken. In general, the water samples were collected at the same time, over the period Jun. 1–Jul. 13. Eight samples of sludge were obtained from one sedimentation basin during the period May 22–Jun. 22. This basin had been cleaned in March and was in use at the time of the rainout of Apr. 26.

The analysis of water and alum sludge samples from the treatment plant showed that about 35 per cent of the raw-water activity was removed by the rapid sand filters. It should, however, be pointed out that this water has a relatively high concentration of manganese and is treated so that 80–90 per cent of this element is deposited upon the filter sand. This fact may account, at least in part, for the removal of fission products by these filters. The wash water showed activities as high as 0.39 $\mu\mu c$ per milliliter (Jun. 10).

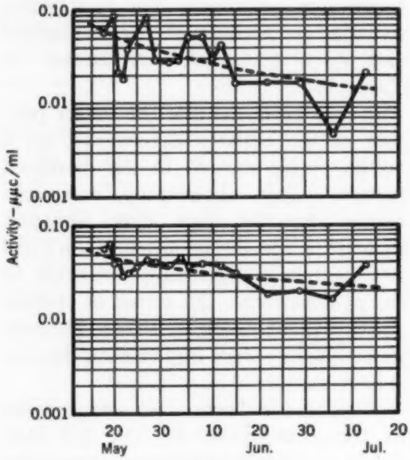

Fig. 5. Alcove and Loudonville Reservoir Activity

Top: sampling point at surface of Alcove intake; die-out equation, $A = 1.8t^{-1.1}$. *Bottom: sampling point at center basin of Loudonville Reservoir; die-out equation,* $A = 0.4t^{-0.6}$.

The 35 per cent overall removal was less than the amount anticipated before this study was begun. No appreciable removal of fission products by aeration and sedimention could be detected, even though the alum sludge revealed both beta and alpha activity. It should be pointed out that these data do not reflect the efficiency of the treatment

processes immediately after a rainout, because of the lapse of time between the Apr. 26 rainout and the date on which the first samples were taken from the treatment plant.

The Loudonville Distribution Reservoir consists of three uncovered concrete basins. A sampling station was established at the center basin, and samples were collected on the same schedules as for the other reservoir studies. A plot of the radioactivity determination is given in Fig. 5. The die-out curve, shown as a broken line, was calculated as for Alcove Reservoir and represents the curve of best fit. It may be noted that the concentration of fission products in this water was practically the same as in the water from Alcove Reservoir. It therefore appears that storage of the filtered water in this uncovered reservoir nullifies, partially at least, the advantage gained in the treatment process.

Schenectady Supply Samples

Samples of ground water from the Schenectady supply showed a wide variation in activity. Those taken on May 24 were inactive. A sample collected on Jun. 4 had an activity as high as 0.097 $\mu\mu$c per milliliter. In the last sample, collected on Jul. 5, the activity had fallen to 0.01 $\mu\mu$c per milliliter. The high activity of the Jun. 4 sample was outside the range of counting error and could not be accounted for.

Acknowledgment

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Water Quality Criteria and Municipal Supplies

By W. W. Towne

A paper presented on Sep. 10, 1953, at the Ohio Section Meeting, Cleveland, Ohio, by W. W. Towne, Officer in Charge, Ohio & Tennessee Drainage Basins, Div. of Water Pollution Control, US Public Health Service, Cincinnati, Ohio.

WATER quality, to most people, is a relative matter, depending upon what they have become accustomed to. A hard water to a Bostonian might be considered extremely soft by many midwesterners. Continuous use breeds tolerance, and the parameters by which the individual judges water quality may likewise be relative rather than absolute.

Early efforts to improve the quality of municipal water supplies were directed at the removal of turbidity. The first filters for a city wide supply were constructed in 1804, at Paisley, Scotland, and by 1829 the London water supply was also being filtered *(1)*. These developments took place long before it was recognized that bacteria caused disease or that water might serve as a vehicle for their transmission. As the role of bacteriology in the field of sanitation became established—not until near the close of the last century—the water works profession devoted its energies and abilities largely to improving the sanitary quality of water used for domestic purposes. The success of these efforts may be gaged by the relative absence of waterborne disease in the urban population. In fact, today the average water consumer takes for granted the bacterial safety of the municipal supply.

The Massachusetts Board of Health instituted the first systematic program of sanitary water analyses in 1887, and by the beginning of the twentieth century such analyses were well established procedures. With the development of analytical methods designed to measure the sanitary characteristics of water, it was natural that quantitative limits should be applied in the interpretation of the results. Some of the first standards were concerned with the quality of the water from the standpoint of whether or not it would cause disease.

The first federal water quality standards were the "Treasury Department Standards," promulgated by the US Public Health Service in 1914 *(2)*. These were developed for the sole purpose of controlling the quality of water supplied to the public by common carriers engaged in interstate traffic. Specifically, these standards referred only to bacteria, including the total number of bacteria on agar plates at 37°C and the presence of *"Bacillus coli"* as determined by the fermentation of lactose broth.

Probably because these were among the first standards to be adopted by any type of control agency, and because they were applied to those municipal water supplies furnishing

drinking water to common carriers, the "Treasury" standards were used as a parameter to measure the bacterial quality of municipal water supplies in general by many state and local health departments.

As additional knowledge became available, the federal standards were revised and improved (*2*). In 1925 limits were imposed upon the permissible concentrations of lead, copper, and zinc. The total bacterial count at 37°C was dropped and the limits for *Esch. coli* were revised. Limiting concentrations of other constituents were also set forth, but as recommendations only. As in the 1914 standards, these requirements were developed for the control of water supplies used by interstate carriers. More and more frequently, however, they were applied to municipal supplies, and the 1946 revision was accepted by the AWWA as a voluntary standard for all public water supplies (*3*).

The 1946 standards established certain mandatory limits relating to bacterial quality and physical and chemical characteristics. They also recommended limiting concentrations for other, less critical, substances. In general, the mandatory limits were placed upon those substances known to be detrimental to the health of the consumer. The extent to which these standards may be applied to water supply systems other than those of common interstate carriers, and the enforcement of such requirements, are purely a function of the state and local governments. With the possible exception of the bacteriological standards, it is believed that both mandatory and recommended limits are used by the states principally as guides and not as rigid specifications. In general, this statement is probably also true for "standards" that have been officially adopted by several states. For the most part these standards are in the nature of objectives and guides on which judgment may be based in determining the relative suitability of a public supply. The US Public Health Service standards, of course, apply to the water as it is delivered to the consumer. The average consumer is concerned primarily only with the quality of water as it comes from his tap and as it may affect his senses of sight, taste, and smell. Although the water department is cognizant of the consumers' demands and desires, at the same time it is keenly aware of the great difference in quality that may exist between the raw material and the finished product. This has led to an endeavor to establish quality requirements for natural waters, a subject that has aroused considerable interest, discussion, and controversy, and about which much has been written.

Need for Flexible Criteria

Realizing that the quality of natural waters may be beyond the control of regulatory agencies—or, at least, may not be immediately amenable to complete correction—many regulatory agencies have used the words "criteria" or "objectives" rather than "standards" in this connection. "Standards" imply definite and fixed rules, whereas "criteria" are a means of forming judgment, and "objectives" suggest desirable ends to be reached eventually but not necessarily at once.

In defining water quality requirements, regardless of whether or not they are called standards, criteria, or objectives, it must always be borne in mind that the establishment of a limiting concentration must be related to a specific water use. For a given sub-

stance, a concentration that is entirely satisfactory for one use may be extremely objectionable for another. For example, the maximum limit of 250 ppm chlorides in the 1946 "Drinking Water Standards" is higher than can be tolerated by some industrial operations. Consequently, it is impossible to establish a single standard having the same relative degree of suitability for all water uses.

Because water uses will not remain fixed, and because future developments may indicate the need to revise present requirements, any system of water quality control must be flexible, realistic, and practical. Rigid standards do not appear to be the best means to accomplish this end. Rather it would seem desirable to establish objectives based upon judgment after the many variable factors have been fully considered.

In addition to the difficulties associated with fixed standards, the effects of various substances upon the quality of water for domestic use are as yet largely unknown. With the rapid growth of the chemical and other industries during the past two decades, numerous complex wastes are finding their way into the watercourses used as sources of public supply. How consumers are affected by many of these substances and what concentrations are safe are not known. Questions regarding the possible toxicity of trace concentrations over long periods of exposure are also unanswered.

Many water works operators, however, are fully cognizant of the difficulties involved in treating waters polluted with such wastes. In several instances, all known treatment processes have failed to produce a tasteless and odorless water, and the cost of treatment has almost always increased materially. One city reports that the expense of treating Ohio River water has risen from $2.50 per million gallons in 1925 to approximately $11. Only a portion of this increase may be attributed to higher prices. These are but a few of the reasons why water works officials, particularly those dealing with surface water, are vitally concerned with natural-water quality objectives.

Limiting Concentrations

Some of the earliest studies leading to the development of limiting standards for natural waters used as sources of public supply were conducted by the US Public Health Service. These studies established the safe permissible limits of raw water pollution that were consistent with the production of effluents meeting the 1925 "Drinking Water Standards" (*4*). The recommended raw-water coliform-organism limits (*"B. coli"* index per 100 ml) were: 50 for water systems with simple chlorination only; 5,000 for systems with rapid sand filtration and postchlorination; and 20,000 for systems with rapid sand filtration and both pre- and postchlorination.

These limits have been used extensively by the water works profession and public health authorities for the past several years as guides in determining the suitability of polluted surface waters as sources of public supply. Several state and interstate agencies have also developed standards or criteria for natural waters used as sources of domestic supply. The Ohio River Valley Water Sanitation Commission (*5*) has adopted the following bacterial quality objectives; "Water Supply Uses —The monthly arithmetical average 'most probable number' of coliform organisms in waters of the river at water intakes should not exceed 5,000 per 100 ml in any month; nor exceed this

number in more than 20 per cent of the samples of such waters examined during any month; nor exceed 20,000 per 100 ml in more than 5 per cent of such samples." The commission is also giving consideration to the development of water quality objectives for fluorides, phenolic compounds, and other substances associated with industrial wastes.

The results of a most thorough study of existing water quality criteria, undertaken by the California Institute of Technology for the California Water Pollution Control Board, were published (*6*) in 1952. This valuable reference is recommended to all persons concerned with water quality. In reviewing the standards or criteria promulgated by various regulatory agencies, the California report noted that the standards for natural waters used for domestic purposes tended to follow a definite pattern and that it was possible to group such requirements according to degree of suitability as a source of public supply. Table 1, quoted from this report, provides an excellent summary of the ranges of limiting threshold concentrations for raw-water sources of domestic water supplies.

TABLE 1

Limiting and Threshold Concentrations for Domestic Supply

Item	Suitability as Supply Source		
	Excellent*	Good†	Poor‡
BOD—*ppm*			
Monthly 5-day avg	0.75	1.5–2.5	2.0–5.5
Max. day or sample	1.0	3.0–3.5	4.0–7.5
Coliform organisms—*MPN/100 ml*			
Monthly avg	50–100	240–5,000	10,000–20,000
Max. day or sample		20%, 5,000; 5%, 20,000	
DO			
Avg—*ppm*	4.0–7.5	2.5–7.0	2.5–6.5
Saturation—*per cent*	50–75	25–75	
pH (avg)	6.0–8.5	5.0–9.0	3.8–10.5
Chlorides (max.)—*ppm*	50	250	500
Fe & Mn (max.)—*ppm*	0.3	1.0	15
Fluorides—*ppm*	1.0	1.0	1.0
Phenolic compounds (max.)—*ppm*	none	0.005	0.025
Color—*ppm*	0–20	20–70	150
Turbidity—*ppm*	0–10	40–250	

* Requires disinfection only.
† Requires ordinary treatment, such as filtration and disinfection.
‡ Requires special or auxiliary treatment and disinfection.

Conclusion

Water for drinking and other domestic purposes is generally regarded as having priority over all other uses. It may be expected that regulatory agencies with jurisdiction over public water supplies and control of water pollution will give appropriate consideration to preserving the supply for this use. It must be recognized, however, that the demands on the nation's limited water resources are constantly increasing. It has been estimated that the water requirements for the United States will approximately double within the next 25 years. The largest percentage increase and the largest increase in quantity will be for industrial purposes. Growing demands have already resulted in competition for water in many areas.

Insofar as municipal supplies are concerned it is not so much a question of obtaining sufficient quantity as of obtaining water of proper quality. It is the author's opinion that the water consumer will continue to demand additional improvements in quality. Consequently, it may be expected that water quality requirements for municipal supplies will become more exacting. At the same time the increased use and reuse of water is sure to add some degrading constituents, and the water works profession may well be confronted with the problem of producing a better and better product from sources that are constantly decreasing in quality as a result of pollution.

The time is past, in many areas, when one source of supply could be abandoned for another of higher quality. Therefore, the water works man has a growing stake in preserving the quality of the raw materials on which he has to rely—the nation's water resources.

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Reprints of the following articles, published in the Journal during the preceding year, will be available from the Association in small quantities, at the prices noted, until the present stock is exhausted. Order by reprint number and author's name from: Order Dept., American Water Works Assn., Inc., 521 Fifth Avenue, New York 17, N.Y. Prepayment is required from nonmembers. (Note: This list does not include specifications and similar documents kept permanently in stock.)

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Recommended Specifications for Stationary Chlorine Storage Installations

The Chlorine Institute, Inc.

These specifications have been developed by a special committee of producers of chlorine. This document is not to be regarded as an official statement of The Chlorine Institute, Inc., or of the American Water Works Assn. The specifications are published for information only—to be considered by such users of chlorine as may wish guidance in setting up stationary chlorine storage installations.

The references to specific equipment and producers thereof, contained in the specifications, are not represented as being inclusive of all producers of such equipment. The lists include those producers known to the special committee that drew up the specifications.

Section 1—Introduction

Sec. 1.1—Disclaimer

1.1.1. The information contained herein is drawn from sources believed to be reliable. The safety suggestions are based on the accident prevention experiences of a number of members of The Chlorine Institute, Inc. The institute and its members make no guarantee, jointly or severally, of results and assume no liability, jointly or severally, in connection with the information herein contained or the safety suggestions herein made. Moreover, it should not be assumed that every acceptable safety procedure is contained herein; or that abnormal or unusual circumstances may not warrant or require further or additional procedure. These suggestions should not be confused either with state, municipal, or insurance requirements, or with national safety codes.

1.1.2. Bulk consumers of chlorine usually withdraw chlorine for their processes directly from a single-unit chlorine tank car on a private siding. The Chlorine Institute does not recommend stationary chlorine storage by consumers for safety reasons, including the following:

a. Most consumers do not constantly have available responsible personnel with the specialized training and experience required for design, operation, and maintenance of stationary chlorine storage installations.

b. In the event of a serious chlorine leak, most consumers would not have available means of quickly disposing of the chlorine.

c. In the event of fire, chlorine stored in a tank car may be removed from the fire area, while stationary storage tanks lack such a safety factor.

Sec. 1.2—Purpose

The purpose of this specification is to record typical procedures and equipment for stationary chlorine storage installations:

a. Where circumstances indicate that such storage is necessary; and

b. Where adequate provisions have been made to overcome successfully

the three objections to stationary storage which are listed in Sec. 1.1.2.

Sec. 1.3—Scope

1.3.1. This specification applies to stationary chlorine storage installations in a general way only, for it is not possible to anticipate all local conditions and specialized problems which may be encountered. Depending upon local conditions, the modification of some designs set forth in this specification may be in accord with good practice. The experienced technical staffs of chlorine producers have developed many alternative and satisfactory procedures for use by such producers for their own stationary storage installations. It is not possible to include all such variations in this recommendation.

1.3.2. Manufacturers of some items of equipment which have been found to be satisfactory for use with chlorine are identified herein, but it is not to be assumed that their products are endorsed by The Chlorine Institute. Such product listings are intended to aid persons seeking information on typical acceptable equipment. The listings are not held to be complete, nor should it be assumed that equivalent equipment will not give satisfactory service.

Sec. 1.4—Regulatory and Insurance Requirements

Location, capacity, design, maintenance, and operation of chlorine stationary storage installations may be subject to regulation by local, state, and provincial governments, and insurance companies. Owners of stationary chlorine storage installations should, therefore, verify that they fully comply with such requirements. It should be noted that this specification is advisory and has no force in law.

Sec. 1.5—Personnel

It is essential that stationary chlorine storage installations be constantly under the supervision of trained, responsible personnel. Personnel should thoroughly understand the properties of chlorine (see Reference 6.1). They should be drilled periodically in the use of gas masks and other emergency equipment and in procedures to be followed in the event of chlorine leakage. Design of equipment cannot overcome personnel deficiencies.

Sec. 1.6—Definitions and Terminology

It should be understood that, for the purpose of this specification, the terms listed below, unless otherwise noted, shall be held to have the following meanings:

a. "Chlorine" refers to dry chlorine in either the gaseous or liquid phase.

b. "Tanks" refers to stationary chlorine storage tanks.

c. "Code" refers to one of the editions of "Rules for Construction of Unfired Pressure Vessels," Sec. VIII, of the American Society of Mechanical Engineers Boiler Construction Code as listed in Sec. 2.3.2. herein.

d. "Maximum allowable working pressure" refers to this term as used in the Code.

Section 2—Location, Capacity, and Design of Tanks

Sec. 2.1—Location of Tanks

2.1.1. Before installing tanks, approval of the proposed location should be obtained from any authorities having jurisdiction.

2.1.2. Where practicable, tanks should be located in lightly populated areas.

2.1.3. The direction of prevailing winds should be considered in locating

tanks in order to minimize the possibility of leaking chlorine being blown into a densely populated area.

2.1.4. Tanks should be located so as to minimize external corrosion of them by acid gases or liquids.

2.1.5. Tanks should be located so as to minimize the possibility of the installation sustaining damage by vehicular traffic.

2.1.6. It is essential that tanks be located in an area where they will not be exposed to fire. Flammable materials should be kept away from the storage area.

2.1.7. Tanks should be located aboveground and outside of buildings and placed so that total length of piping will be kept to a minimum.

2.1.8. Under certain conditions, diking of storage tanks is desirable.

Sec. 2.2—Capacity of Tanks

2.2.1. The capacity of tanks should be the minimum quantity consistent with consumption.

2.2.2. There should be provided at least one spare tank of a capacity equal to the capacity of the working tank. The working tank and spare tank should be operated alternately and independently, with no cross connection between them.

Sec. 2.3—Design of Tanks

2.3.1. Approval of design of stationary chlorine storage installations should be obtained from any authorities having jurisdiction.

2.3.2. Except as specifically noted, tank shells should be fusion welded, fully radiographed, and stress relieved, and should be designed, constructed, inspected, tested, and marked in accordance with Paragraph U-68 or U-200 of the 1949 edition of "Rules for Construction of Unfired Pressure Vessels," Sec. VIII, of the American Society of Mechanical Engineers Boiler Construction Code (Reference 6.2) or equivalent provisions of later editions of the Code.

2.3.3. Tanks should be designed for a maximum allowable working pressure of 225 psig (pounds per square inch gage) or greater.

2.3.4. Minimum wall thickness of tanks should be $\frac{1}{8}$ in. greater than is required by the design formula for the maximum allowable working pressure of the tank.

2.3.5. Tanks should have only one opening, to be located on the top. This opening should be an 18-in. nozzle equipped with a standard 33-in. tank car manhole cover plate as specified in the current revision of The Chlorine Institute's Drawing B-345.* Valves and safety valves located on the manhole cover plate should be protected with a standard chlorine tank car protective housing. (See Reference 6.3 or 6.4.)

2.3.6. Tanks should be provided with strong, noncombustible supports on footings extending below the frost line. They should be mounted on saddles designed and spaced so as to prevent concentration of excessive loads on the tank shells and in such a manner as to permit contraction and expansion due to temperature variations. Saddles should be welded to the tanks before stress relieving. Wherever tanks rest on saddles which are not welded to them, tanks should be supported on asphalt-impregnated wood blocks. Provision should be made, where necessary, to prevent flotation of tanks by flood waters. Adequate crawl space should be provided for

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* Prints of Drawing B-345, "Standard Dimensions of 33-in. Dome Cover Plate, Class 105A," may be obtained from The Chlorine Institute, Inc., 50 E. 41st St., New York 17, N.Y.

maintenance purposes. If a weighing device or strain gage is to be used to measure tank contents, supports should be designed for this purpose.

2.3.7. There should be no welding in the field to tanks or their parts except as specifically authorized by the Code.

2.3.8. Tanks should be insulated with a suitable material (such as cork board or glass) which is resistant to chlorine and will maintain its insulation properties in the event of fire. The insulation material preferably should be of a thickness so that the thermal conductance is not more than 0.075 Btu per square foot, per degree Fahrenheit differential in temperature, per hour.

2.3.9. Insulated tanks should be thoroughly protected by asphalt or paint coating from corrosion of the steel by condensed moisture. Insulation should then be applied and the outside of the insulation sealed and weatherproofed.

Section 3—Valves, Piping, and Appurtenances

Sec. 3.1—Safety Valves

3.1.1. Each tank should be provided with one or more safety valves of the spring-loaded type of design suitable for use with chlorine. Unless specifically excepted herein, protection of tanks with safety valves should be in accordance with the requirements of the Code. Rupture discs should not be used in lieu of safety valves. Safety valves should be mounted on the manhole cover plate.

3.1.2. Safety valves should be set to open at a pressure not in excess of the maximum allowable working pressure of the tank. Safety valves should be set to reclose at a pressure not less than 80 per cent of set pressure. Safety valves should have a total relieving capacity sufficient to prevent a maximum pressure in the tank of more than 120 per cent of the maximum allowable working pressure, using the heat input as determined by Fetterly's formula. (See Reference 6.3.)

3.1.3. Typical safety valves which are suitable for use with chlorine are the following or their equivalent:

a. American Car and Foundry Co., Drawing No. 21-614, Types 1121, 1122, and 1123.

b. Crosby Steam Gage and Valve Co., Drawing No. D-13105, Revision D. (This design is The Chlorine Institute Standard for use on chlorine single-unit tank cars. The breaking-pin device on this valve is covered by US Patent No. 2,098,399, dated Nov. 9, 1937, assigned to Olin-Mathieson Chemical Corp., Baltimore, Md., by whom it has been made available, royalty free, for stationary chlorine storage use.)

Sec. 3.2—Valves

3.2.1. Valves should be of a type specifically designed for chlorine service.

3.2.2. Angle and globe valves of bolted bonnet construction with outside screw and yoke are recommended with body, bonnet, and yoke of forged or cast carbon steel and trim of Monel or "Hastelloy C." * Valves should have a deep packing recess containing packing such as braided graphitized asbestos or equivalent, or molded "Teflon." †

3.2.3. Typical angle valves for use on the tank manhole cover plate are the following or their equivalent (this design is The Chlorine Institute

* A product of Haynes Stellite Div., Union Carbide & Carbon Corp., New York.

† A product of E. I. du Pont de Nemours & Co., Wilmington, Del.

Standard for use on chlorine single-unit tank cars):

a. American Car and Foundry Co., Drawing No. 31-52-293, Type 1301.

b. Darling Valve and Mfg. Co., Drawing No. F-60717

c. Seren Tool and Mfg. Co., Drawing No. V-1000.

3.2.4. Typical valves which should be suitable for use with chlorine on the piping system are the following or their equivalent:

a. Crane Co., Drawing No. 1644, 1645, 1654, and 1655.

b. William Powell Co., Drawing No. 3031, 3033, 6030, 6031, 6032, and 6033

c. Henry Vogt Machine Co., Series No. 663 through 668

d. Wallace and Tiernan Inc., Drawing No. 9549.

3.2.5. The Chlorine Institute standard-design ton container valve might be useful at some points of the installation. These valves may be obtained from such suppliers as the following: Aluminum and Brass Co., Kerotest Mfg. Co., Mueller Brass Co., Superior Valve and Fitting Co., or Wallace and Tiernan Inc.

Sec. 3.3—Excess-Flow Valves

The two angle valves located on the longitudinal centerline of the manhole cover plate should be designated as liquid valves. Beneath each liquid valve there should be a suitable excess-flow valve such as the following or equivalent:

a. American Car and Foundry Co., Drawing No. 117-22011, Type 1411, or General American Transportation Corp., Drawing No. 22222. (This design is The Chlorine Institute Standard for use on chlorine single-unit tank cars. This valve is covered by Patent No. 2,615,676, assigned to Columbia-Southern Chemical Corp., Pittsburgh, Pa., to whom application should be made for a royalty-free license to use the valve in chlorine storage tanks.)

b. American Car and Foundry Co., Drawing No. 11–8193, Type 1412, or General American Transportation Corp., Drawing No. 15072.

Sec. 3.4—Eduction Pipes

3.4.1. Beneath each angle valve located on the longitudinal centerline of the manhole cover plate, an eduction pipe of 1¼-in. extra-heavy (Schedule 80) seamless steel pipe should be provided.

3.4.2. The lower ends of the two eduction pipes should be cut off at an angle of 60 deg to the axis of the pipe, and the lower ends should be located ½ in. above the bottom of the tank. The upper end of each eduction pipe should be screwed into the excess-flow valves fastened to the lower side of the manhole cover plate.

3.4.3. Drop pipes projecting below the gas valves to a point one-fifth of a tank diameter below the top will aid in preventing overfilling of the tank.

Sec. 3.5—Gaging Devices

3.5.1. It is essential that reliable means be provided for determining at any time the amount of chlorine in a tank in order to prevent overfilling of the tank with resultant hazard of loss of chlorine from development of excessive hydrostatic pressure.

3.5.2. Weight-measuring devices are to be preferred for gaging chlorine tanks because of their reliability, the ease with which they may be maintained, and the fact that they do not require an additional opening to be made in the tank which might provide a source of leakage. The tank may be mounted on scales, and the weight of the tank and appurtenances can be balanced by tare beam and the weight of

chlorine read directly. Or the tank may be gaged by supporting one end of the tank on a load-measuring element or equivalent such as supplied by Baldwin-Lima-Hamilton Corp. or Taylor Instrument Companies.

3.5.3. Gage glasses should not be used.

Sec. 3.6—Piping

3.6.1. Extra-heavy (Schedule 80) seamless steel pipe should be used for chlorine piping. Where flexibility is required, as with connections to tank cars, a loop of Type K (extra-heavy) copper tubing may be used, fitted with flanges as specified in Sec. 3.7.

3.6.2. Steel pipe should be bent hot and protected from quick cooling, or, if bent cold, should be stress relieved after bending, to prevent the pipe from becoming hard and brittle.

3.6.3. Joints should be welded or flanged. Piping fabricated by welding should have ferrules inside the joints to back up the welds. Flanges as specified in Sec. 3.7 should be placed in every other length of straight-run piping and adjacent to valves to facilitate inspection and repair.

3.6.4. The use of threaded joints should be minimized, but, where they are necessary, it is of the greatest importance, in order to avoid leaks, to use clean, sharp dies to obtain smooth, clean threads. White lead, red lead, or litharge and glycerine may be used as pipe dope. Apply dope to the male thread only, in such a manner as to prevent its entrance into the piping system. All joints should be made as tight as possible without distorting the pipe.

3.6.5. Piping should be free of unnecessary obstructions, well supported, and not exposed unnecessarily to heat. Provision should be made for expansion of piping due to temperature changes. Long liquid-chlorine lines should be avoided. Piping should be sloped toward the tank to facilitate draining of the lines. Avoid low pockets where moisture may collect and cause corrosion.

3.6.6. Long lines should be protected with shutoff valves at each end. Except when required by an emergency, both valves should not be closed at the same time. Protect piping between shutoff valves at the highest point with expansion chambers of at least 20 per cent of the piping volume between the valves. The purpose of the expansion chambers is to prevent the development of excessive hydrostatic pressure in the line from liquid chlorine trapped between valves. An inverted cylinder or vertical, sealed pipe section may be used as an expansion chamber. Expansion chambers should be located in a heated area in a building to prevent condensation of chlorine at elevated pressures. If this is not practical, the expansion chambers may be installed in an enclosure, with heat provided by incandescent light bulbs.

3.6.7. Means should be provided to prevent condensation of chlorine in chlorine gas lines.

Sec. 3.7—Flanges

Forged-steel 300-lb weld neck flanges, slip-on welding flanges, or threaded flanges, all with ASA small tongue-and-groove facings, faced and drilled, are acceptable. Forged-steel tongue-and-groove ammonia flanges are also acceptable. Typical flanges which should be suitable for use with chlorine are obtainable from such suppliers as the following: Crane Co., Frick Co., Taylor Forge and Pipe Works, Tube-Turns, or York Corp.

Sec. 3.8—Fittings

3.8.1. Schedule 80 forged-steel welding tees and ells are acceptable. Typical fittings which should be suitable for use with chlorine are obtainable from such suppliers as the following: Crane Co., Taylor Forge and Pipe Works, or Tube-Turns.

3.8.2. Cast-steel 300-lb flanged ells and tees with ASA small tongue-and-groove facings, faced and drilled, are acceptable. Forged-steel tongue-and-groove ammonia flanges are also acceptable. Typical fittings which should be suitable for use with chlorine are obtainable from such suppliers as the following: Crane Co., Frick Co., William Powell Co., or York Corp.

3.8.3. Forged-steel 2,000-lb elbows and tees, screw end, are acceptable. Typical fittings which should be suitable for use with chlorine are obtainable from such suppliers as the following: Crane Co. or Henry Vogt Machine Co.

Sec. 3.9—Gaskets

Gaskets should be of lead containing 3 per cent antimony or should be of bonded asbestos fiber per Military Specification MIL-A-17472 (Navy) or equivalent. For pipe smaller than 2-in., use gaskets $\frac{1}{16}$ in. thick; for pipe 2 in. and larger, use gaskets $\frac{1}{8}$ in. thick.

Sec. 3.10—Pressure Gages

Pressure gages should be designed for chlorine service and should be either the diaphragm-protected type or the forged-steel welded Bourdon tube type. Suitable diaphragms may be made of Monel, silver, or tantalum. A pressure range of not less than 0–250 psig is desirable. Suitable gages for use with chlorine are the following or their equivalent:

a. Crosby Steam Gage and Valve Co., Style AA-P or A-10

b. Manning, Maxwell, and Moore, Catalog No. 1072A or 1079B

c. US Gage Div. of American Machine and Metals, Inc., Figure 578A

d. Wallace and Tiernan Inc., Type U-1134.

Sec. 3.11—Flowmeters

Flow of chlorine gas may be measured by orifice type flow meters or rotameters specially designed for chlorine service. A glass wool and dried activated carbon filter should be installed ahead of the rotameter. (Activated carbon as received contains moisture. Dry with hot air before installing.)

Sec. 3.12—Lighting

Provision should be made for adequate lighting of stationary storage installations as an aid in dealing with possible emergencies which might occur at night. Battery-operated lights should be available in case of power failure.

Sec. 3.13—Protective Equipment

3.13.1. Gas masks of a type approved by the US Bureau of Mines for chlorine service should always be readily available. Gas masks should be located at more than one location outside of the probable area of contamination so that it will be possible to reach them in an emergency. Gas masks should be used and maintained in safe operating condition in accordance with directions of the supplier of the mask. Personnel should be drilled periodically in the use and location of gas masks.

3.13.2. Gas masks of the absorbent canister type do not supply oxygen—they absorb chlorine in the air. Canister type masks are inadequate in air containing more than 1 per cent of chlorine. Under such conditions, a

self-contained oxygen breathing apparatus, or a fresh-air hose mask should be used. Suppliers of all types of gas masks approved by the US Bureau of Mines for chlorine service are listed in Bureau of Mines Information Circular 7636 (see Reference 6.5).

3.13.3. Emergency equipment has been developed for temporarily controlling leaks that may occur at the manhole cover plate and at the valves of chlorine single-unit tank cars. These emergency kits may be used with stationary tanks which are provided with standard manhole cover plate, valves, and standard ICC tank car dome as recommended. With the use of these kits, leaks may be stopped until the chlorine remaining in the tank is used in the consuming process or absorbed in an alkaline solution. It is recommended that such kits be available at each storage installation. (See Reference 6.6.)

Sec. 3.14—Cleaning, Drying, and Testing Piping System

3.14.1. *Cleaning.* All parts of equipment which may come into contact with chlorine must be free of oil before being put into service. Valves and other equipment should be dismantled and thoroughly cleaned with suitable solvent. Valves should be repacked, if necessary, with suitable packing, such as braided graphitized asbestos or equivalent. Any pipe dope which may have collected on the inside of pipes should be carefully cleaned out. All oily and greasy matter inside the pipe should be removed with suitable solvent.

3.14.2. *Drying.* Since moisture may have entered the system during construction, the system should be thoroughly dried before being put into service. This may be accomplished by passing steam through the system from the high end until it is thoroughly hot, allowing the condensate and foreign matter to drain out. While the system is still hot, dry air (having a dew point of −20°F) should be blown through the line until the wet- and dry-bulb temperatures of air leaving the system correspond to wet- and dry-bulb temperatures of air entering it. Valve packing should be removed before steaming.

3.14.3. *Testing.* Valves should be tested under pressure for seat tightness before installation. For greatest safety, chlorine piping systems should be hydrostatically tested to a pressure of 300 psig before the system is dried. After drying, it should be filled with dry compressed air and tested for leaks with soapy water. Small quantities of chlorine gas may then be introduced into the line and the desired test pressure built up with dry compressed air. Tests for leakage should be made by bringing an ammonia swab close to joints and watching for formation of white fumes. Any leaks thus detected must not be repaired by welding until all chlorine has been purged from the line. When detectable leaks have been stopped, the line may be tested at the desired pressure with full-strength gaseous chlorine in the system.

Section 4—Operation of Stationary Chlorine Storage Installations

Sec. 4.1—Method of Filling Tanks

4.1.1. Stationary chlorine storage tanks are usually filled from a single-unit chlorine tank car by introducing clean, dry air under pressure into one of the gas valves of the tank car and thus forcing liquid chlorine through a liquid valve of the tank car into storage. This procedure is known as "air padding," and may also be used for

transferring liquid chlorine from the storage tank to process when necessary.

4.1.2. Air is detrimental to certain chlorine-consuming processes; therefore, unless suitable means are available for removing the air, air padding should not be used by consumers employing such processes. Under these circumstances, consumers should consult with the chlorine supplier.

4.1.3. In air padding chlorine single-unit tank cars and stationary storage tanks, it is essential that certain safety precautions be observed. Typical of such precautions are the following:

a. Pressure within a tank being air padded must be carefully limited to prevent loss of chlorine through the safety valve.

b. The air supply for padding must be dry and free from oil and foreign matter.

c. The air supply for padding must not be part of the plant air system; an independent air compressor should be used solely for this purpose.

4.1.4. A detailed specification on the subject of air padding, including a diagram of a typical air-padding system, is available upon request from The Chlorine Institute (Reference 6.7).

4.1.5. Trained, responsible personnel should supervise the transfer of chlorine from tank car to storage tank.

4.1.6. For precautions to be observed in unloading single-unit chlorine tank cars, refer to the "Chlorine Manual" (Reference 6.1).

Sec. 4.2—Maximum Filling Limit of Tanks

It is extremely important that the weight of chlorine in a tank should at no time exceed 125 per cent of the water capacity of the tank. A tank filled to this maximum limit will have about 12 per cent gas space at 68°F, into which the liquid chlorine may expand if its temperature rises further. Under normal atmospheric conditions, this gas space is sufficient to prevent the tank from becoming liquid full. If the tank should become liquid full, there would be a risk of loss of chlorine due to the hydrostatic pressure which would be built up within the tank and cause the safety valve to open.

Section 5—Maintenance of Stationary Chlorine Storage Installations

Sec. 5.1—Need for Maintenance

To promote safety in the storage of chlorine it is necessary that a systematic schedule be established for inspecting and maintaining the installation in order that potential defects may be prevented or detected and corrected before they present a hazard. In addition to full compliance with any applicable requirements of municipal, state, and provincial governments and insurance companies, maintenance practices should at least conform to the standards herein set forth.

Sec. 5.2—Inspection and Test of Tanks

5.2.1. Frequency of inspection and tests of tanks should be as follows:

a. At intervals of 2 years or less tanks should be hydrostatically retested and show no leakage or distress at a pressure not less than $1\frac{1}{2}$ times the maximum allowable working pressure of the tank, or at a higher pressure if such was required for the original test of the tank by the Code under which the tank was constructed.

b. At intervals of 2 years or less the interior surface of tanks should be visually inspected for corrosion, pitting, cracks, checking, or other defects.

c. The condition of the insulation should be inspected annually for watertightness. If there is evidence of the possibility of exterior corrosion, the insulation should be removed and the exterior surface of the tank should be visually inspected for defects. The insulation should then be replaced and waterproofed as specified in Sec. 2.3.9.

5.2.2. A procedure for visually inspecting and hydrostatically testing tanks follows:

a. Emptying tank of chlorine and opening tank. Empty tank of all possible liquid chlorine. Blow dry air into tank until effluent is chlorine free, allowing effluent air to pass through waste gas absorption system. With tank at atmospheric pressure, disconnect all lines to tank and remove safety valve.

b. Filling tank with water. Completely fill tank with water as rapidly as possible through one or more angle valves. Do not leave the tank standing partially full, as selective corrosion occurs at the waterline. While filling, add caustic soda or soda ash to keep contents alkaline to litmus paper. After tank is filled, continue adding water for about an hour and overflow to the sewer through a temporary connection on the safety valve opening.

c. Testing. Attach a $\frac{3}{4}$-in. 500-lb vent valve to the safety valve opening. Connect test pump and 0–500-psig pressure gage. Apply prescribed hydrostatic pressure, shut off inlet valve, and hold pressure for not less than $\frac{1}{2}$ hr and preferably longer. Record pressure initially and after $\frac{1}{2}$ hr. There should be no appreciable drop in pressure when testing hydrostatically, as this would indicate weakness of the tank, provided there are no leaks in the system. Weighing (gaging) devices should be checked for accuracy when the tank is empty and when it is full of water.

d. Emptying tank of water and preparing for entry. Open vent valve and remove pressure from the tank. Blow out water with air or siphon out water. Remove manhole cover plate. Blow out tank with steam, followed by air. Before a man enters a tank, the atmosphere should be tested for oxygen content. The man who enters a tank must wear a safety harness with rope and be attended at all times by a man outside the tank. A ladder should be used inside the tank.

e. Washing, drying, and inspecting tank. A man should enter the tank and scrub the interior using a broom and hose. Use a scraper or wire brush to remove any remaining traces of scale. The water in the bottom of the tank should be siphoned out while the man inside keeps the water stirred up to carry off as much dirt as possible. When all the water that can be siphoned out has been removed, manually remove any sludge which remains and wipe the tank with dry rags. Blow hot air into the tank until it is completely dry. Air should be blown through an air line to reach each end of the tank to obtain maximum drying. Leave the air purge on overnight to dry the surface further. Brush the dry surface to remove any loose particles which remain. Inspect the interior of the tank for dryness, dirt, corrosion, cracking, pitting, or checking. Marks on the surface of the tank show up more clearly if the beam of light from a flashlight is directed parallel to the surface being inspected. Wax impressions should be made of any pits or irregularities ($\frac{3}{16}$ in. or deeper) and filed with a description

of the location of the pits for future reference. If repairs should be made to the tank as a result of inspection, welding and stress relieving should be performed in accordance with the requirements of the Code under which the tank was constructed, and the tank should be retested before being returned to service.

f. Returning tank to service. Check to make certain that no rags, scrapers, or other articles remain in the tank. Replace manhole cover plate and supply with new or reconditioned eduction pipes and excess-flow valves, and with new gasket. Examine condition of manhole cover plate studs and bolts and replace when necessary. Install new or reconditioned angle valves, safety valve, gaskets, and piping. After making sure that the air in the tank is thoroughly dry, introduce chlorine gas and air mixture into tank and hold pressure at about 100 psig for 24 hr. All fittings and joints should be tested for leaks during this period with an ammonia bottle. Blow down tank and retighten all bolts on the manhole cover plate. Return the tank to service.

Sec. 5.3—Maintenance of Other Equipment

5.3.1. *Safety valves.* At the time of testing tanks, the safety valve should be placed in a test jig and subjected to gradually applied pressure, and a record made of its pop and reseating pressure. The valve should then be disassembled, cleaned, reground, if necessary, and reset. If a Chlorine Institute Standard Safety Valve is used, it should be examined and tested in accordance with Sec. 4 of "Maintenance Instructions for Chlorine Institute Standard Safety Valve" (See Reference 6.8). Testing and handling require special techniques and equipment. In most cases, it will be advisable to have a spare valve available and, if a Chlorine Institute Standard Safety Valve is used, to make arrangements with a chlorine producer or with the Crosby Steam Gage and Valve Co. to test and examine it.

5.3.2. *Valves.* At the time of testing tanks, valves should be disassembled and cleaned, the packing replaced, and the valves seat tested for gastightness at 300 psig.

5.3.3. *Excess-flow valves.* At the time of testing tanks, excess-flow valves should be cleaned and reconditioned, condition of seat and pins inspected, and ball replaced.

5.3.4. *Eduction pipes.* At the time of testing tanks, eduction pipes should be steamed out, dried, and inspected.

5.3.5. *Gaging devices.* Weight-measuring gaging devices, the only type recommended, should be protected from corrosion.

5.3.6. *Piping, flanges, and fittings.* Protect piping and fittings from corrosion and inspect periodically to determine advisability of replacement.

5.3.7. *Gaskets.* Renew gaskets at the time tanks are tested.

5.3.8. *Pressure gages and flowmeters.* Maintain in accordance with instructions of the manufacturer.

5.3.9. *Protective equipment.* A schedule of regular and frequent (not less than once every 3 months) inspections should be established to assure that all gas masks and emergency devices are maintained in readiness for reliable service in an emergency.

Sec. 6—References

6.1. The Chlorine Manual. The Chlorine Institute, Inc., 50 E. 41st St., New York 17, N.Y. (2nd ed., 1954).

6.2. Rules for Construction of Unfired Pressure Vessels, Section VIII, ASME Boiler Construction Code. Am. Soc. Mech. Engrs., 29 W. 39th St., New York, N.Y.

6.3. Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water Including Specifications for Shipping Containers. Issued as Tariff No. 9 by Bureau of Explosives, 30 Vesey St., New York, N.Y.

6.4. Board of Transport Commissioners for Canada Regulations for the Transportation of Explosives and Other Dangerous Articles in Rail Freight and Rail Express Service, Including Specifications for Shipping Containers. Issued by Railway Assn. of Canada, 1520 Mountain St., Montreal, Que.

6.5. List of Respiratory Protective Devices Approved by the Bureau of Mines. Information Circular 7636, Bureau of Mines, US Dept. of Interior, Pittsburgh, Pa.

6.6. Kit "C" Instructions for Applying Solvay Emergency Devices for Stopping Chlorine Leaks From ICC Class 105A 16- and 30-Ton Chlorine Tank Cars. Solvay Process Div., Allied Chemical & Dye Corp., 61 Broadway, New York, N.Y. (May 1947).

6.7. Consumer Air Padding of Chlorine Single Unit Tank Cars. The Chlorine Institute, Inc., 50 E. 41st St., New York 17, N.Y.

6.8. Maintenance Instructions for Chlorine Institute Standard Safety Valve. The Chlorine Institute, Inc., 50 E. 41st St., New York 17, N.Y. (4th ed., 1954).

APPENDIX

Addresses of Manufacturers

The addresses of manufacturers mentioned in the specifications are listed below:

Aluminum & Brass Co.
120 Church St.
Lockport, N.Y.

American Car & Foundry Co.
30 Church St.
New York 7, N.Y.

Baldwin-Lima-Hamilton Corp.
60 E. 42nd St.
New York 17, N.Y.

Columbia-Southern Chemical Corp.
420 Fort Duquesne Blvd.
Pittsburgh 22, Pa.

Crane Co.
836 S. Michigan Ave.
Chicago 5, Ill.

Crosby Steam Gage & Valve Co.
Wrentham, Mass.

Darling Valve & Mfg. Co.
Williamsport 28, Pa

Frick Co.
W. Main St.
Waynesboro, Pa.

General American Transportation Corp.
135 S. La Salle St.
Chicago 90, Ill.

Kerotest Mfg. Co.
2525 Liberty Ave.
Pittsburgh 22, Pa.

Manning, Maxwell & Moore, Inc.
250 E. Main St.
Stratford, Conn.

Mueller Brass Co.
Port Huron, Mich.

Olin-Mathieson Chemical Corp.
Mathieson Bldg.
Baltimore 3, Md.

William Powell Co.
2525 Spring Grove Ave.
Cincinnati 22, Ohio

Seren Tool & Mfg. Co.
1800 W. Fulton St.
Chicago 12, Ill.

Superior Valve & Fitting Co.
1509 W. Liberty Ave.
Pittsburgh, Pa.

Taylor Forge & Pipe Works
Box 485
Chicago 90, Ill.

Taylor Instrument Cos.
95 Ames St.
Rochester 1, N.Y.

Tube-Turns, Inc.
224 E. Broadway
Louisville 1, Ky.

US Gage Div.
American Machine & Metals, Inc.
Sellersville, Pa.

Henry Vogt Machine Co.
1000 W. Ormsby St.
Louisville 10, Ky.

Wallace & Tiernan Inc.
25 Main St.
Belleville 9, N.J.

York Corp.
Roosevelt Ave. & P.R.R.
York, Pa.

Engineering Studies on Amebiasis Outbreak at South Bend

By George G. Fassnacht and Jack H. Fooks

A contribution to the Journal by George G. Fassnacht, Chief, Water Supply Section, State Board of Health, Indianapolis, Ind., and Jack H. Fooks, Water Supply Consultant, US Public Health Service, Region 8, Denver, Colo.

ALTHOUGH official statements have not yet been released on the cause of an outbreak of amebiasis involving an industrial plant in northern Indiana, it seems desirable to outline for the water works profession some of the engineering studies that were carried out on the water supply concerned. Amebiasis is considered to be infection with the ameba, *Endameba histolytica.* The clinical symptoms include, but are not limited to, those of amebic dysentery.

On Mar. 16, 1953, a sanitary engineer and the state epidemiologist met with the South Bend, Ind., city health officer to investigate two recently reported cases of amebiasis. The patients were two men working in the same factory. A week later two more cases were reported, again employees of this factory. Health records revealed that three of the four South Bend cases of amebiasis during the previous year had also worked in the plant in question.

This was not an explosive outbreak such as has come to be expected in a waterborne epidemic. Neither was there clearcut evidence of the abnormal diarrhea indicative of gross sewage contamination in a water supply. The picture was still further clouded because the date on which a case was reported did not necessarily coincide with the time of onset, which might have been months earlier. Data compiled by the US Public Health Service Communicable Disease Center at Atlanta, Ga., indicate that there were never more than three new cases a week among workers in the South Bend factory (Table 1), a fact that was not known at the start of the investigation.

As in any outbreak of an unusual disease, recognition of its existence in the community focused the attention of practicing physicians on it, and cases were more quickly diagnosed. Medical laboratories continued to report individuals who were infected with *E. histolytica* during late March and April 1953. When a total of 25 was reported for South Bend in a 6-week period, additional personnel were assigned to an epidemiological team and a complete investigation was ordered.

It was the purpose of the medical epidemiologists to find some evidence from information furnished by known cases that would point to the method

of transmission or the source of infection. Sanitarians investigated such normally suspected vehicles as food, food handlers, and dairy products. The sanitary engineers turned their attention to the water supply and its possible contamination.

When one looks back calmly on an epidemiological investigation, after all the data have been gathered and are spread before him, it is easy to see just what course should have been followed, what shortcuts should have been taken, and what avenues of study should have been pursued more diligently or completely ignored. But work under pressure during an actual epidemic is never like that. New cases are reported each day from some unknown source of infection, which must be found and eliminated. Basing his actions on the information at hand, the investigator follows the most expedient course that will lead to that source.

Plumbing Survey

During the latter part of March, when there were only four cases of amebiasis on record and when it had been shown that two of the four food handlers in the factory cafeteria were carriers of ameba cysts, the engineers were not inclined to accept too seriously the theory that drinking water was the vehicle of infection. They took at face value the information given on the plant water supply and made a spot check of the plumbing for interconnections that might permit back siphonage.

Only two water closets, in one of the newer washrooms at the far end of the plant distribution system, had flush valves without siphon breakers. All other toilets had high flush boxes. There were three physical connections between potable-water and fire lines in the powerhouse. The telltale "weep holes" showed none in use, and powerhouse personnel denied knowledge of any occasion within the preceding several years on which they had been used. The factory management was

TABLE 1

Amebiasis at South Bend Industrial Plant *

Date	No. of Cases	Remarks
1950		
Jul.–Sep.	0	frequent unsatisfactory water
Oct.–Dec.	3	samples; chlori-
1951		nator installed in
Jan.–Mar.	0	Sep. 1951
Apr.–Jun.	2	
Jul.–Sep.	0	
Oct.–Dec.	0	water samples "satisfactory"
1952		
Jan.–Mar.	0	
Apr.–Jun.	2	
Jul.–Sep.	2	
Oct.–Dec.	0	
1953		
Jan.–Mar.	14	
Apr.–Jun.	8	change to city water May 7, 1953
Jul.–Sep.	0	

Week of Onset, 1953	No. of Cases	Week of Onset, 1953	No. of Cases
Jan. 4	0	Mar. 22	2
11	0	29	3
18	0	Apr. 5	1
25	0	12	2
Feb. 1	2	19	1
8	2	26	0
15	1	May 3†	0
22	1	10	0
Mar. 1	3	17	1
8	2	24	0
15	1		

* Data from Communicable Disease Center, USPHS, Atlanta, Ga.

† Change to city water May 7, 1953.

most cooperative. Siphon breakers were installed immediately, and the connections to the fire lines were broken as recommended. A tap was installed ahead of the chlorinator to permit weekly sampling of the raw water.

The first step in the full investigation that began on May 1 was a thorough inspection of the plumbing. Starting at the high-service pumps in the powerhouse, the engineers checked the main water line and all branches, risers, laterals, and fixture connections. With a plant plumber as a guide, and a large-scale print of the property for orientation, the size and location of each pipe in the crawl space under the buildings were found and noted. Every lateral and riser was then examined as far as the final fixture or plugged end. This was no small undertaking, because the plant comprises approximately 750,000 sq ft of floor space on 65 acres of ground.

All toilet fixtures, in 47 separate locations, were of types in which there could be no back siphonage from the bowl, with two exceptions, and the latter had been equipped with siphon breakers, as previously mentioned. Two interconnections with cooling or makeup water at the boilers were not considered significant because of the temperature of the water and the character of the application. Steam-water mixing valves at sinks and process basins throughout the plant were likewise exonerated. Five instances of direct connection of cooling water to one side of a machine and direct connection to the sewer drain on the other were noted. If the building drains had been stopped up, and if the machine involved had been in operation at a time of low or negative water pressure, it would have been possible for contaminated material to have been drawn into the potable-water system. Building drains were not checked to determine whether fecal material could have been part of such potential contamination, because the medical epidemiologist had, by then, developed data indicating that the infection was too widespread, and the distribution too uniform throughout the plant, to have been caused by spot contamination of the drinking-water supply.

Fifteen or 20 years previously the toilets had been flushed from the fire sprinkler lines. The plumber reported that he had checked the whole system a couple of times for each of three successive power plant superintendents without finding any cross connections. During the vacation period in August 1952 the entire potable-water system was drained, leaving blowoff valves open under each building, while 100-psi pressure was maintained on the fire line. The absence of flow from the drains in an 8–10-hr test period was considered proof that cross connections did not exist. This draining could have produced back siphonage and general contamination of the plumbing under certain circumstances but did not, however, appear to have any relation to the 1953 outbreak.

Partly because the factory management, insisting that a steady pressure of 60 psi at the powerhouse meant no low pressures in other buildings, viewed the plumbing survey with skepticism, recording pressure gages were placed at critical points. It was found that pressures on the top floor of the building farthest from the pump dropped to zero in periods of peak use during normal plant operation. By flushing the lines in the crawl space of

this building, as is done routinely twice a week, it was possible to draw air into at least one of the risers. Because the water system is not looped, however, conditions at its extremes had little significance as an explanation for the general outbreak.

Water Supply

At the time of the investigation, water for the fire sprinkler system came from a dug well approximately 40 ft in diameter and 40 ft deep. The static water level was 20.5 ft. Potable, boiler, and industrial water normally was pumped from a gravel-packed drilled well with this log: fill, 0–4 ft; dry sand, 4–20 ft; sand, 20–62 ft; hard clay, 62–90 ft; sand (25 ft of screen), 90–118 ft. This well had a vertical turbine pump rated at 400 gpm when new, in 1946. It discharged to a 1,300-gal receiving tank under atmospheric pressure in a concrete underground vault or pit. Chlorine solution from a gas chlorinator, wired to operate with the pump, was applied just ahead of the tank. From the receiving tank, the water passed through a 6-in. bell-and-spigot cast-iron pipe to a pair of high-service, steam-driven, reciprocating, double-acting, governed pumps in the powerhouse basement. The steam pump suction header was approximately 18 in. lower than the receiving-tank outlet. The pumps discharged though a pressure tank, at varying rates up to an estimated 500–600 gpm, to the branching distribution system. There was no recirculation of water.

City water was also available at the high-service pump suction. This standby potable-water supply had to be repumped to provide adequate pressures in all parts of the plant.

As indicated in Fig. 1, a number of dug wells and, more recently, air lift wells in the plant area had formerly been used as sources of water. All the abandoned wells were said to have been filled, except for the dug well under the powerhouse floor, which is used to drain the pump room.

It was recognized that the location of the gravel-packed well supplying potable water did not meet current standards. The well was of double tubular construction, however, and took water from sand under nearly 30 ft of clay. It had no record of contamination by coliform organisms.

Bacteriological Studies

There had been trouble with this industrial drinking-water supply during 1949, when a local laboratory found coliform organisms in numerous bacteriological samples from the plant distribution system. In December of that year a State Board of Health field engineer, cooperating with the city health officer, examined the water supply. Although the gravel-packed artesian well was within 30 ft of two storm sewers, samples of well water and repumped water from the powerhouse were satisfactory bacteriologically; however, six of eleven samples from drinking fountains throughout the plant contained coliform organisms. As there had been extensive replacement of pipe in the various buildings, disinfection of the whole plumbing system was recommended and continuous chlorination of the supply was suggested. At that time there was no hint of amebiasis.

Sanitary engineers have long been familiar with the US Public Health Service standards for coliform-organism density in relation to safe drinking

water. As many as 10 per cent of all the standard 10-ml portions examined in a month may contain coliform organisms before the water is considered to be of questionable safety. Occasionally three or more of the five 10-ml portions constituting a standard sample may contain coliform organisms

TABLE 2

Results of Coliform Tests on Unchlorinated Water

Sampling Point*	Date	No. of Positive 10-ml Tubes	Beyond Powerhouse		Sampling Point*	Date	No. of Positive 10-ml Tubes	Beyond Powerhouse	
			No. of Samples	No. Positive				No. of Samples	No. Positive
DW	7/19/49	0			DW	6/18/53	0		
DW	7/26/49	0			P	7/19/49	0	6	3
DW	10/7/49	0			P	9/12/49	?	3	1
DW	11/9/49	0			P	9/28/49	0	2	2
DW	11/9/49	0			T	10/10/49	0	2	1
DW	4/14/53	0			T	11/9/49	0	10	3
DW	4/20/53	0			T	2/20/51	0	5	1
DW	4/27/53	0			PL	5/3/53	2	6	5
DW	5/7/53	0			PM	5/3/53	3		
DW	5/7/53	0			SPD	5/17/53	2		
DW	5/17/53	1			SPD	5/19/53	1		
DW	5/19/53	0			SPD	5/20/53	0		
DW	5/20/53	0			SPD	5/22/53	0		
DW	5/22/53	0			SPD	5/22/53	0		
DW	5/22/53	0			SPD	5/23/53	0		
DW	5/23/53	0			SPD	5/24/53	0		
DW	6/16/53	0			SPD	6/16/53	0		
DW	6/16/53	0			SPD	6/16/53	0		
DW	6/17/53	0			SPD	6/17/53	0		
DW	6/18/53	0			SPD	6/17/53	5		

* Key: DW—drilled well; P—powerhouse; PL—powerhouse laboratory; PM—powerhouse meter; T—pressure tank; SPD—steam pump discharge.

and still represent an acceptable water, if certain other conditions are met.

Interpretation of available bacteriological data for the factory was difficult because, until late in 1952, the laboratory reports did not show the number of tubes planted, the number positive, or the media used. The reports read simply: "Cultures yield *B. coli*" or else "No *B. coli* found." A detailed study of the records, however, showed that all eight samples collected at four different times from the distribution system during 1948 were free of *Esch. coli*. A report of the next sampling, on Jan. 3, 1949, showed coliform organisms at a drinking fountain in the front office but none at the fountain in the engineering office. A sampling seven days later indicated no coliform bacteria at either the front office or the cost department office in the same building with the engineering office. Sporadic positive samples continued to be noted until the first part of October 1949, at which time the only good samples were those from the well or the powerhouse. By

the middle of the month positive reports were once again being received occasionally, a condition that lasted until mid-December, when, for a 2-week period, fourteen of 22 samples contained coliform organisms. From January through August 1950 only five samples out of 82, or 6.2 per cent, were unsatisfactory, although many unsatisfactory samples were reported thereafter. Following the installation of a chlorinator in September 1951, however, there was only one sample containing coliform organisms up to May 1953.

One of the sampling points contributing unsatisfactory results was a gatehouse served only by municipal water. City records for a frequently sampled tap within a block of this location reported the water as being free from coliform organisms.

All five samples from the drilled well, and four out of five from the pressure tank or powerhouse, during the last half of 1949, were negative for coliform organisms (Table 2). Some samples taken on the same days from the plant were positive, while others were negative. Resampling a fixture after an unsatisfactory report usually produced a satisfactory sample. No samples of unchlorinated well water in the plumbing system had been analyzed since early in 1951. As cysts of *E. histolytica* are not harmed by the chlorine residuals normally maintained in water supplies (*1, 2*), it was entirely possible that this organism might exist in the drinking water even after the coliform bacteria indicating fecal contamination had been killed. Plans were made to shut off the chlorinator and sample the system following a flushing period on the first weekend during which the plant was not in production. Beginning about noon Sunday, May 3, 1953, 18 hr after the chlorinator had been shut off, water samples were collected at the locations shown in Table 3. Tests indicated no chlorine residual in any of the samples. Five 10-ml portions were planted from each, with results as given in Table 3.

As soon as the incomplete 48-hr laboratory findings were reported, it was recommended that city water be used instead of the private supply until the source of contamination could be found and removed. This action was taken because of the poor environment of the water source, as well as the presence of contamination in the samples from the plant distribution system. Although well samples had been satisfactory, a test gage placed on the suction side of the high-service pump had indicated negative heads on the pipe from the receiving tank to the pump.

TABLE 3

Coliform Test Sampling Points

Sampling Point	No. of Positive 10-ml Tubes
Powerhouse laboratory	2
Powerhouse meter	3
Room 25—finishing	3
Room 14—filling	1
Room 26—shipping	3
Room 16—warehouse	0
Room 23—warehouse	1
Room 26—finishing	2

Tests on Water Supply

By mid-May the medical epidemiologists were convinced that the current outbreak, at least, was caused by the plant water supply. They had ruled out food, food handlers, dairy products, and general sanitation deficiencies found in the factory as potential vehicles of transmission (*3*).

It became increasingly apparent, as information was gathered and studied, that any contamination of the factory water supply which would explain the outbreak must have entered between the 1,300-gal receiving tank and the high-service pumps. Furthermore, negative heads of 6 and 15 in. of mercury had been noted on the suction header, and, although the exact route of the 6-in. cast-iron line was not known, it had to cross the path of the powerhouse sewer at one or more places to get to the high-service pumps.

A quick qualitative leakage test was applied to the pipe between the receiving tank and the pumps—this pipe will hereafter be referred to as the suction line—by attaching a hose from the city water line to the header at the steam pumps. As the suction line was filled, the valve at the receiving tank was closed. A gage on the header then read 60 psi but dropped to 30 psi in 8 min when the valve to the city water line was closed.

To determine the size of the leak, a 55-gal drum was placed on the powerhouse roof and connected to the header with a hose. When the drum and suction line were filled with water, a gage on the header read 24 psi and leakage was measured at 10 gph (less than 0.25 gpm) from the drum. This leakage occurred under pressures approximately three times as great as the maximum suction observed during normal operation.

With negative head and leakage both demonstrated on the suction line, the next logical step was an attempt to draw dye from the sewer into the water line. Fluorescein dye was prepared in aqueous solution and permitted to drip from cans into a urinal and a sink in the powerhouse. While one high-service pump discharged city water to the factory distribution system, the other was adjusted to discharge to the sewer at a rate of approximately 10 gpm, with a suction of 15 in. of mercury. It was thus possible to experiment with dye in the sewer without detriment to the drinking water. Hourly samples from the pump discharge were collected and examined with a portable ultraviolet lamp during two 24-hr periods. The observed fluorescence was too indefinite to permit any positive conclusions. Later, in a laboratory, the samples were viewed again under a mercury vapor light with an ultraviolet filter. Although there was general agreement among the observers that differences existed among the samples, all observers did not rate them in the same order of intensity. About a week later it was possible to have the samples checked on an electronic photofluorometer by a scientist familiar with the operation of the instrument. The same inconclusive results were noted. One sample from a municipal well field half a mile from the factory and some of the blanks from the factory well were as positive as the samples from the suction header.

In an effort to determine whether ground water might be diluting the dye to less than an observable concentration, a hole was opened beside the powerhouse sewer, approximately 20 ft south of Manhole No. 7 (Fig. 1). Local water company employees previously had attempted to find the suction line with electric pipe-locating equipment and believed that it probably ran north from the receiving tank past the dug well, angled northeast between the well and the fire pumps to the line of the powerhouse sewer, and then followed the sewer to the powerhouse.

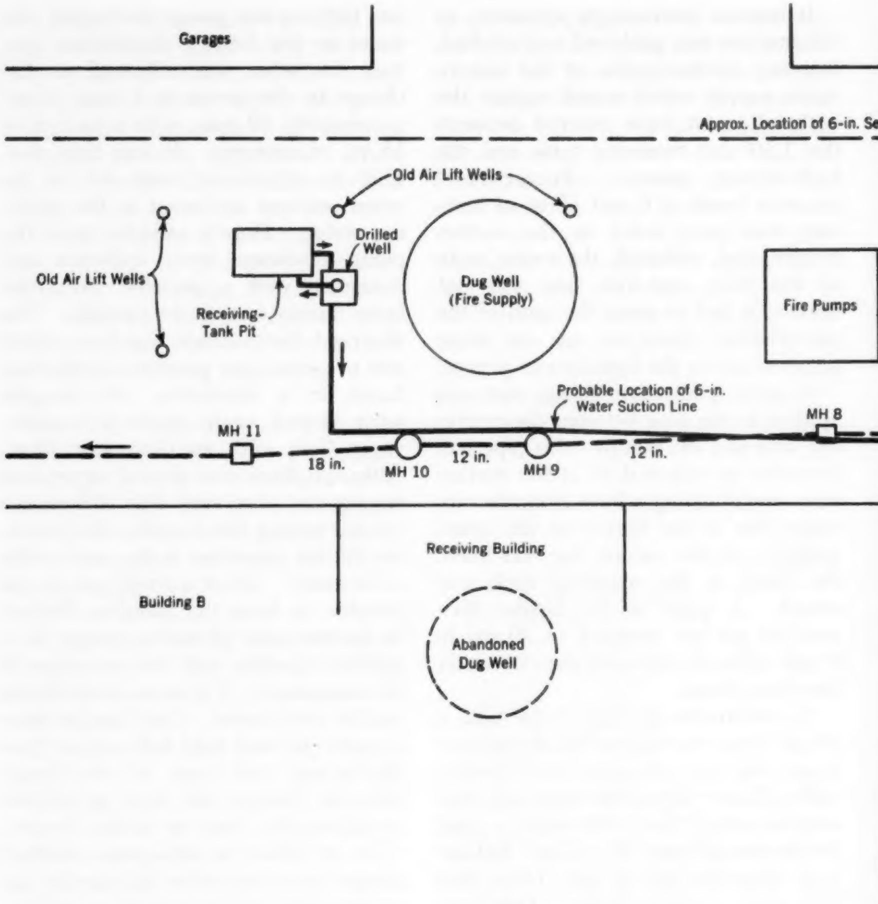
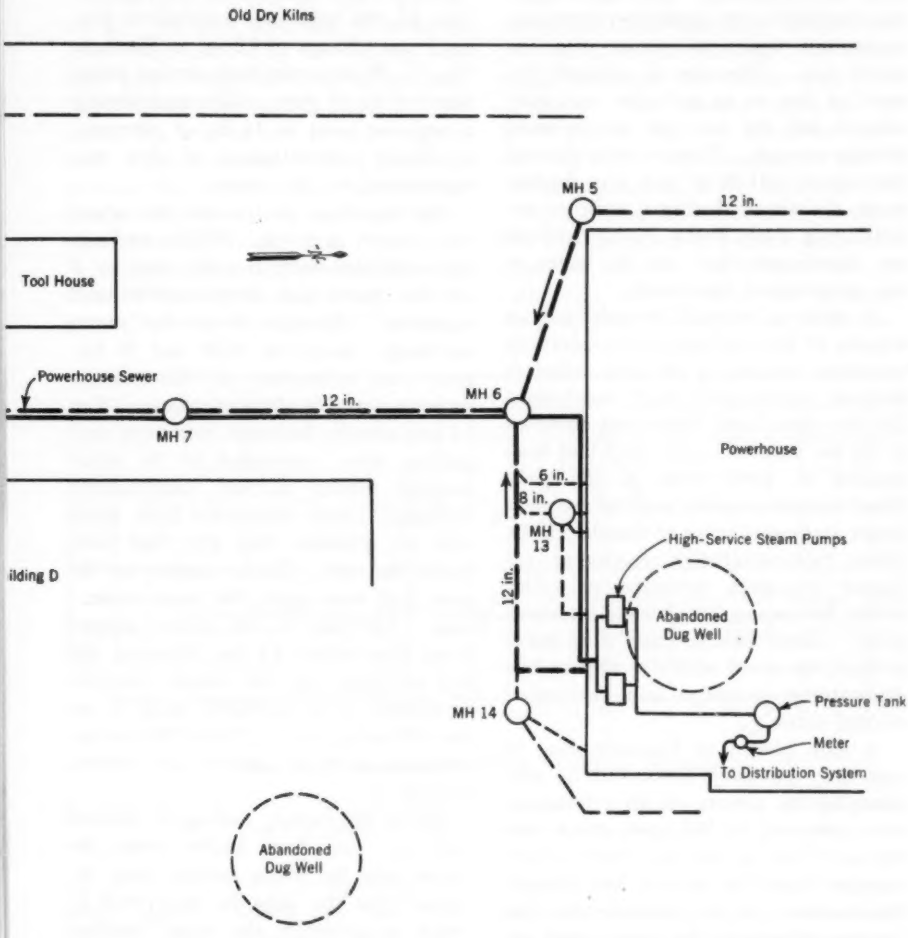


Fig. 1. Factory Well Area and Location of Piping

Factory veterans verified the location and recalled that both the sewer and the water pipe had been laid in the same trench with the water line 6 ft below the sewer.

These recollections were partially correct. The top of the cast-iron sewer pipe was found 48 in. underground, while 6-in. and 10-in. cast-iron lines, presumed to be fire sprinkler system mains, were found about 42 in. down, lying respectively 2 in. east and 36 in. west of the sewer. A fourth cast-iron pipe, 6 in. in diameter, was located 5 in. east of the sewer, with both flow lines at approximately the same elevation. The top foot of excavated material consisted of cinders and fill, and



the rest was all fine yellow sand. No ground water was encountered.

Tapping hammer listening devices borrowed from the local water company were of no value in identifying the fourth pipe. Attempts to identify it by measuring the drop in potential when voltage was impressed on the suction line at the powerhouse also failed. The unknown line was finally assumed to be the suction line because it began to sweat when the high-service pump was operated and stopped sweating when the pump was shut off.

With the close proximity of sewer and suction line thus practically established, it was evident that the report of 6 ft of filtering sand between the

two was erroneous. Consequently, it was decided to try again to prove contamination from the sewer into the water line. The use of chloride instead of dye as an indicator was considered, but the test was not believed delicate enough. Plant records showed that about 100 lb of salt was flushed down the sewer during a softener regenerating cycle every 30 hr, without any significant effect on the water at the powerhouse laboratory.

A study of rainfall records and an inquiry of the city engineer concerning municipal sewers in the area failed to indicate surcharged sewer conditions. On the other hand, there was evidence in all the manholes that they had been flooded at some time in the past. Plant workers readily recalled frequent sewer stoppages prior to October 1948, when cation-exchange treatment replaced lime-soda softening of boiler water, but remembered none in recent years. Nevertheless, plans were made to flood the sewer with dye water while maintaining pumpage and suction at normal rates.

A dam placed in Manhole No. 10 was only partially successful in surcharging the sewer. With a pumping rate estimated at 165 gpm and a suction of 15 in. of mercury, none of the samples from the suction line showed fluorescence. Tests demonstrated that the dye mixture in the sewer could not be observed in dilutions greater than 100:1. If the leak was less than 0.25 gpm, the dilution in the suction line would have been greater than 660:1. Hence, the failure of the previous experiment was not surprising.

A small inner tube was mounted on a jig so that it could be inserted in the 18-in. sewer at Manhole No. 11 and inflated to stop the flow completely. When the plant closed on the night of Jun. 17, the tube was installed to produce a surcharge of 12 in. at Manhole No. 7. Flow to the high-service pump was cut to 18 gpm, while maintaining a negative head of 15 in. of mercury. A heavy concentration of dye was maintained in the sewer.

The injection of dye into the sewer was started at 6 PM. Within an hour the manholes were flooded, and by 8 PM the pump had been throttled and regulated. Samples from the pump discharge, taken at 8:20 and 9 PM, gave no indication of fluorescence under a portable ultraviolet lamp. The 11 PM sample, however, was very suspicious when compared to the other samples under normal incandescent lighting. Under ultraviolet light, there was no question that dye had been pulled through. Check samples for the next half hour gave the same indication. The plug in the sewer slipped from place about 11 PM, allowing the dye to drain out, but hourly samples continued to be collected until 7 AM the following day. Photofluorometer readings on these samples are plotted in Fig. 2.

When the factory managers learned that dye had been pulled from the sewer into the water system, they directed that the pipe be excavated in order to ascertain the exact location for its full length. Enough points were uncovered to locate it as indicated in Fig. 1. The management further directed that all plumbing beyond the high-service pumps be disinfected to eliminate any possible remaining contamination. This was accomplished by carrying a 200-ppm chlorine residual in the system for 36 hr during a weekend shutdown.

At all points observed, the cast-iron suction line gave evidence of being in good condition. The tar coating was still intact and the lead-calked bell joints showed no sign of failure. The sewer, too, was of cast iron, in a good state of preservation. Metal had been used for the sewer to resist the thermal shock from alternately carrying boiler blowdown and cold water.

A satisfactory explanation for the cause of the amebiasis outbreak would have to show not only that a point where sewage could contaminate the water supply existed, but also that ameba cysts could be introduced. Even a few inches of fine sand might be enough to filter effectively the water from a leak as small as that found in the suction line. Until the night when dye was pulled from the sewer into the water supply under what were considered to be unusual conditions, the bacteriological record had not particularly incriminated the water source, at either the well or the suction line (see Table 2). The unchlorinated well samples in 1953 had only 1.3 per cent positive 10-ml portions, and the steam pump discharge had 6.0 per cent in 10 samples. The sample collected at 11:10 PM on Jun. 17, when the presence of dye was observed, had a coliform-organism MPN index of 130.

Each exposed portion of the suction line was therefore examined with considerable interest. In Manhole No. 8 (where an oil separator was located) the cast-iron pipe was found half submerged, with a bell-and-spigot joint in the box. During the time the sewer was surcharged for the final dye test, this bell joint was under 1 ft of water. It was not possible to repeat the pressure-leakage test on the line until 2 weeks later. At that time a barrel on the powerhouse roof was again connected to the suction line, the leakage being shown by the loss from the barrel. In addition, the water was colored with a red dye. The leakage measured approximately 27 gph, or

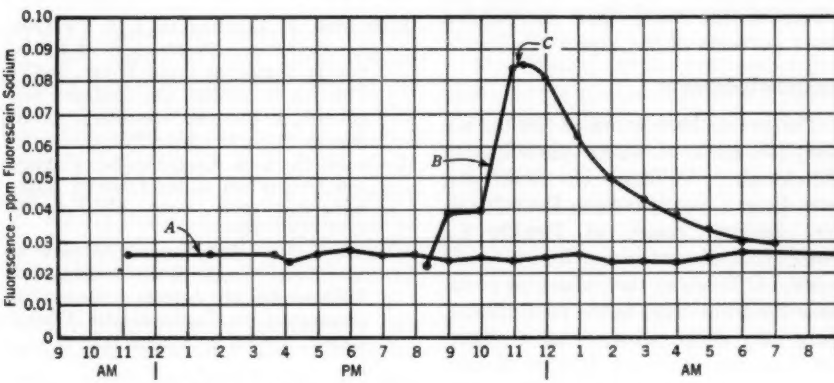


Fig. 2. Fluorescence in Pump Discharge Samples

A—*data for Jun. 16–17, 1953;* B—*data for Jun. 17–18;* C—*sewer plug slipped from place at about 11 pm, allowing dye to drain out.*

about 0.5 gpm. No tests were made to determine if all the leakage occurred at the joint in Manhole No. 8, but colored water oozed into droplets at the top of the calked joint. As one drop was wiped away, another would form. Leakage from the submerged portion of the joint could not be observed directly; water dipped from under the oil slick, however, was very definitely red. It is rather obvious that any sewage which may have entered the suction line from Manhole No. 8 would not have been subject to the filtering action of the sand that surrounded other portions of the pipe.

Acknowledgment

The events here narrated are the accomplishments of many participating individuals. William D. Shillinger, San. Engr., Northwestern Branch Office, Indiana Board of Health, La Porte, Ind., shared in much of the field work. Officials at the industrial plant, from the front office to the powerhouse, were very cooperative. Carl Culbertson, Acting Director, and Raymond Markey, Parasitologist, made available the facilities of the South Bend, Ind., Medical Foundation, as well as their time and knowledge. The authors are indebted also to T. D. Lucky, Chief Biochemist, Lo Bund Labs., Notre Dame University, South Bend, Ind., for analyses made with the electronic photofluorometer, and to the South Bend health and water departments for records and equipment.

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Methods of Controlling Aquatic Growths in Reservoirs

Joint Discussion

A joint discussion presented on May 25, 1954, at the Annual Conference, Seattle, Wash.

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THIS paper is concerned mainly with some of the more recent aspects of microorganism control in New York City's municipal supply. The items included have been selected from a fuller report devoted to a review of past practice, the evaluation of results achieved, organism trends, evaluation of taste and odor situations, new ideas in control, and the perspective of current investigations.

In relatively recent experience, unsatisfactory taste and odor conditions were largely attributable to: [1] the presence of *Synura* in the general supply; [2] the immediate effects of heavy runoff following precipitation; [3] relatively high concentrations of microscopic organisms and, more pertinently, their association with decomposition conditions; and [4] the aftereffects of chlorination in relation to any of the preceding situations. Industrial pollution is not a factor in the New York system.

Taste and Odor Problems

Synura no longer poses an uncertain challenge. Since 1947 superchlorination has proved completely effective in controlling this organism in the Croton supply, and equally effective results have been obtained in the Catskill-Delaware supply by preventive control through the continuous application of small doses of chlorine and copper sulfate.

The department has had occasion to study a type of taste and odor situation that apparently coincides with the course of heavy precipitation and runoff and is not directly correlated with the presence of microscopic organisms. Complaints arise from a sudden outbreak in distribution areas fed most directly from the general source of supply. The duration of the unsatisfactory condition is brief, and complaints subside generally within a few days. The reaction to chlorination is variable; at times even minute doses of chlorine suffice to accentuate the difficulty. Although storage tempers and reduces the objectionable characteristics, desirable detention factors remain to be determined. Where it has been possible to follow up investigations, the history of the organisms in the source of supply has furnished little reason to associate them with the trouble. Coincidence of the pattern of complaint with runoff of conditions and other observations accumulated in the course of surveys indicates that the carriage downstream of decomposition products originating in localized areas is a probable cause.

Heavy concentrations of organisms have proved a source of trouble mainly in local distribution reservoirs. Poor and sluggish circulation, accumulations of debris from varied sources in outlet inverts and in the vicinity of gatehouse structures, and the breeding of insects have been predisposing conditions for unpleasant situations. In such instances, the presence of microscopic organisms may assume a secondary role. Their significance may be symptomatic rather than causative. Such conditions do not lend themselves to ready diagnosis and may continue for a long time without revealing the true cause of the problem. After several years of investigation an opportunity arose during 1953 to illuminate a situation of this type in Jerome Park Reservoir by comparing it with conditions in Central Park Reservoir. Both of these distribution basins are supplied by Croton sources.

This study casts an interesting sidelight on the interpretation of the significance of microorganism populations. During 1953 the Central Park Reservoir effluent on occasion carried organism densities ranging from 500 to 8,000 standard areal units per milliliter without objectionable tastes in the water. The similar distribution of organisms in the Jerome Park effluent, which, however, did not exceed 2,000 areal units per milliliter, was accompanied by variable degrees of taste and odor in about 25 per cent of all samples examined. In both instances, the organisms were predominantly diatoms of the genera *Synedra* and *Fragillaria*. Among other organisms in the Jerome Park effluent, *Melosira, Dinobryon, Monas,* and crustaceans appeared with greater frequency and somewhat higher density than in Central Park. It may be surprising that a diatom, *Melosira,* proved a leading clue to the resolution of the problem. The presence of relatively large numbers of this organism had previously been noted in the upper reaches and shallow areas of the watershed. These areas are prone to show a more active and extensive biological environment, whereas conditions downstream are more and more regressive. *Monas* and heavy densities of crustaceans are often found in such areas. A very detailed field study finally disclosed the accumulation of a considerable amount of heterogenous material deposited in the vicinity of some of the gatehouse structures not used too frequently. These deposits contained soot, silt, corrosion products, remains of insect life, leaves, feathers, and a multitude of organisms, and the mass was in a state of decomposition. It was not surprising to observe large masses of *Melosira.* Integration of these findings with many other factors involved in the investigation led to the conclusion that the specific taste and odor problem in Jerome Park Reservoir was due to the accumulated sediment and its effect upon the aquatic biological environment. It is evident from the foregoing that the presence of microorganism populations is subject to wide interpretations.

The influence of chlorination upon taste and odor is too complex to permit even brief discussion here. Chlorination presents a paradox; its effects on palatability are unpredictable. In the handling of *Synura* in the Croton supply, it has proved more effective than any other method previously employed. On the other hand, under some circumstances, even traces of chlorine suffice to promote aggravated situations. Fortunately these instances are infrequent and relatively isolated. In the period 1940–47 the chlorina-

tion program was revised and the rate of treatment stepped up about threefold. Complaints specifically concerned with chlorination have decreased and today fall into a minor category. Nevertheless, close vigilance must be maintained over its effects to assure a proper balance between taste and odor control and other functions of the process.

TABLE 1

Average Analyses Before Terminal Treatment

Item	Catskill Supply*	Croton Supply†
Turbidity—*ppm*	7	2
Color	9	14
Odor	1.5§	1.5§
Nitrogen—*ppm*		
Albuminoid	0.030	0.110
Free ammonia	0.011	0.048
Nitrite	0.000	0.002
Nitrate	0.14	0.13
Oxygen consumed (O_2)—*ppm*	1.8	3.6
Total solids—*ppm*	36	82
Fixed solids—*ppm*	25	58
Chloride—*ppm*	1.07	3.16
Hardness ($CaCO_3$)—*ppm*	17	47
Alkalinity ($CaCO_3$)—*ppm*	7	32
Iron—*ppm*	0.24	0.10
pH	6.7	7.2
Bacteria per milliliter	17	101
Coliform organisms—*MPN/100 ml*	5.4	13.4
Total organisms—*sau‡/ml*	110	685
Amorphous matter—*sau‡/ml*	373	615
Specific conductance—*micromhos*	44	100
Silica (SiO_2)—*ppm*	2.2	4.0
Calcium—*ppm*	5.0	13.0
Magnesium—*ppm*	0.9	4.5
Sodium—*ppm*	1.7	3.3
Potassium—*ppm*	0.7	1.3
Carbonate (CO_3)—*ppm*	0	0
Sulfate (SO_4)—*ppm*	10.1	17
Fluoride—*ppm*	0.08	0.10
Phosphate—*ppm*	0.03	0.08

* Ashokan gatehouse.
† Croton Lake gatehouse.
‡ Standard areal units.
§ "Vegetable" odor.

Extensive consumer taste and odor reaction surveys conducted during 1946–47 revealed that the normal range of taste and odor intensity in the municipal supplies ran from 0 to 2 cold threshold units. As much of the testing was performed in the field, the determination of "hot" values was not practical. It was further found that an increase in intensity to 3.5 gave rise to sharp and widespread complaints. For odors of decidedly unpleasant character, like those associated with decomposition, a value in excess of 1 often proved significant.

Quality of Supplies

New York is supplied from controlled upland watersheds. The output of the Catskill and Croton watersheds, supplemented by a partial yield from the uncompleted Delaware project, constitutes the bulk of present supplies. They enjoy a high natural purity, are soft, low in mineral and organic content, and free of significant industrial pollution, and in general present relatively few taste and odor problems. The composition of the major supplies is shown in Table 1. Delaware water promises to be very similar to Catskill. These waters are subject to impoundment and consequent natural purification processes. Purification is further augmented by sanitary control, chlorination, and other relatively simple treatment procedures. The supplies are not filtered.

In the spectrum of water supply characteristics, Croton and Catskill would appear to fall within the same grouping, yet their varied reaction to treatment, dissimilarity in taste and odor characteristics, and apparently disproportionate capacities for sustaining microorganism populations indicate a significant difference. With re-

spect to microorganisms, Croton water is over 600 times more productive than Catskill water. The Catskill environment imposes strongly limiting conditions on biological growths. In recent years some steps have been taken to develop a correlation between the nitrogen, phosphate, and organic content of these waters and their microorganism productivities. The accumulated data are still insufficient to warrant even a preliminary hypothesis.

Control Practices

The development of microorganism and taste and odor control in New York City supplies has been discussed in great detail by Hale (*1, 2*). The procedures became well established about 1925 and continued until 1944 with little change. Since 1945 a constant review and reevaluation of treatment procedures has been under way; in its wake, certain changes have taken place. Significant among the newer developments are the improved control of microscopic organisms in Kensico Reservoir and the use of superchlorination in dealing with *Synura* in the Croton supply. In both instances, the use of continuous treatment processes is involved, and surface treatment procedures have been superseded.

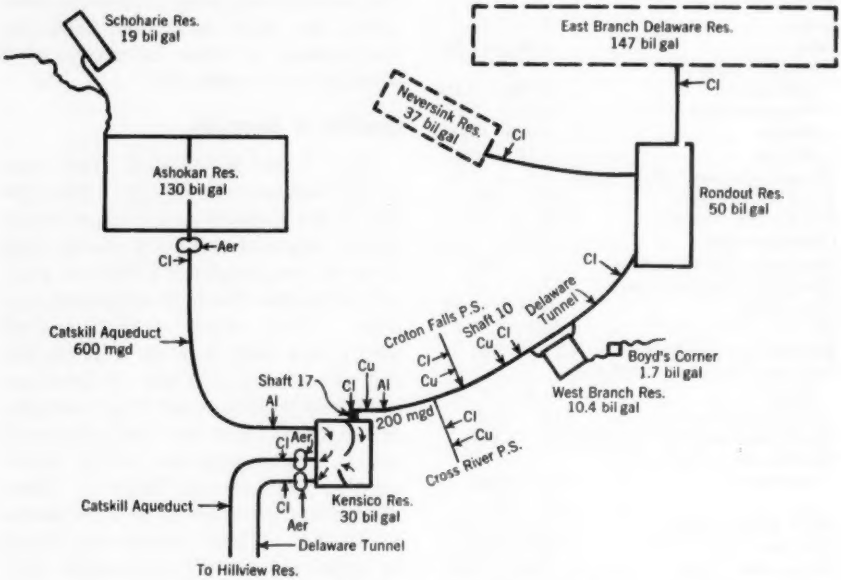

Fig. 1. Catskill-Delaware System Flow Scheme

Treatment employed: Al—alum coagulation; Cl—chlorination; Cu—copper sulfate; Aer—aeration.

Kensico Reservoir

Although numerous variations in operation are possible, normally water from Catskill and Delaware sources

terminates in Kensico Reservoir, from which the supply is carried to the distribution system via two conduits, the Catskill Aqueduct and the continuation of the Delaware Tunnel. A representation of these systems is shown in Fig. 1. The diagram is purely schematic, but functional relationships are correctly presented. (Prior to 1944 the supply for this system was derived solely from Catskill sources.)

Treatment consists of chlorination of the Ashokan effluent, using a dosage of 0.24–0.36 ppm, aeration at this point, and discharge into the upper end of Kensico Reservoir for further storage and detention. On occasion, when turbidity runs high, alum is added at the Pleasantville plant; settling of floc takes place in the upper reaches of Kensico. The usual alum dosage is 8.5 ppm; no lime has been used in recent practice. The water leaving Kensico Reservoir is further chlorinated, the dosage varying from 0.2 to 0.6 ppm, with higher amounts prevailing in more recent years. In the past, when significant growths developed in Kensico, surface treatment with copper was applied to areas of the lake affected. Auxiliary control includes utilization of crude spot treatment de-

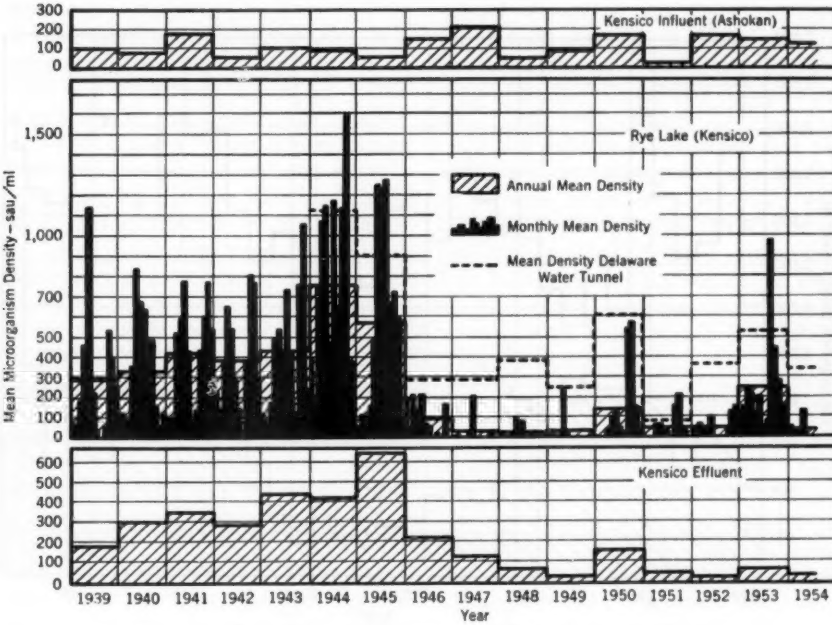

Fig. 2. Microorganism Control in Catskill System, 1939–54

Mean microorganism densities, in standard areal units per milliliter, are given for: the influent from Ashokan Reservoir into Kensico Reservoir (top); the Rye Lake area of Kensico Reservoir and the influent from Delaware Tunnel into Rye Lake since April 1944 (center); and the Kensico Reservoir effluent to New York City.

vices for adding copper sulfate continuously in coves and minor tributary areas with a tendency to develop heavy infestations of microscopic organisms.

Synura has proved a major organism problem and its annual recurrence often involves arduous control measures, especially as it usually occurs in the colder seasons. *Dinobryon* and *Asterionella* also have given rise to unpleasant situations, but with less frequency.

During April 1944 construction of the Delaware project had advanced far enough to permit a partial draft from Rondout Reservoir via the Delaware Tunnel. At the time some concern arose over possible adverse effects upon the general quality of the Catskill supply, because the tunnel combined waters of varying quality with microorganism densities generally many times greater than that introduced by the Ashokan influent. A first step in control was the institution of emergency chlorination at Shaft 17, located on Rye Lake, through which Delaware water is brought into Kensico Reservoir. Initially the chlorine dosage was about 0.4 ppm, but it was subsequently stepped up to 0.7 ppm, the limit of capacity of the temporary installation. These measures failed to halt the upward trend of microscopic organisms in Rye Lake, and in 1946 chlorination was supplemented with continuous ap-

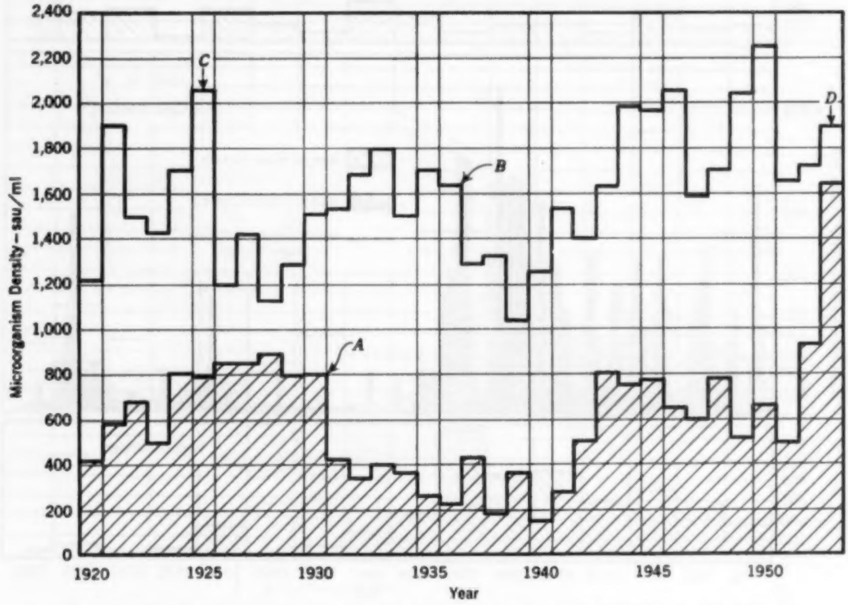

Fig. 3. Microorganism Densities in Muscoot Plant and Croton Lake Effluent

A—*Croton Lake effluent chamber;* B—*Muscoot copper sulfate treatment plant;* C—*continuous copper sulfate treatment began;* D—*no copper sulfate treatment. Microorganism densities are in standard areal units per milliliter.*

plication of copper sulfate at an average rate of 0.18 ppm. The results exceeded set objectives: densities of organisms were brought down to unprecedented levels, and at the same time the *Synura* problem disappeared. Since 1946, with one minor exception, supplementary surface treatments have not been required in Kensico Reservoir.

The condition of microscopic organisms in Kensico Reservoir since 1939 is represented in Fig. 2. The situation prior and subsequent to 1944 and the marked improvement since 1946 are evident. From the experience upon which these data are based, the following observations can be made:

1. Rye Lake has been a dominant factor in the existence of microscopic organisms in Kensico, partly because of its relatively isolated position and the influence of poor circulation and localized drainage conditions.

2. The introduction of Delaware influent in 1944 improved circulation and effected other changes in the localized environment, but did not obviate the need for supplementary treatment measures.

3. Although chlorination of the Delaware input is necessary for numerous reasons, its role in managing microscopic organisms remains to be defined. Efficiencies of about 75 per cent in microorganism reduction have been observed within the confines of the Delaware Tunnel with a 1-ppm dosage, but the regressive tendency is not maintained following discharge into the open reservoir. On the other hand, the marked effect of copper sulfate, even at the small dosage of 0.18 ppm, is obvious. This reaction to copper sulfate was further confirmed during 1953, when the treatment was generally suspended and 1 ppm chlorine was used alone. The rise in annual mean organism density that followed exceeded any since 1945. The resumption of copper treatment in 1954 was marked by a return to very low values.

4. The rise in the number of organisms in Rye Lake and Kensico during 1950 was a consequence of drought conditions in 1949–50. The copper sulfate dosage at the time averaged about 0.18 ppm; it is likely that an increased dosage would have held the organisms down, but this was a matter of little consequence.

5. It should be emphasized that the very significant change of water quality in Kensico Reservoir after 1945 was achieved through partial treatment of the supply—that portion traversing Rye Lake. Actually about 25 per cent of the entire Kensico output was treated, at an added cost of less than 5 cents per million gallons.

Croton Supply

Taste and odor control in the Croton supply has a much longer history than that in the Catskill, and has been associated closely with the control of microscopic organisms. The problem also presents more difficulties, some of which have been discussed heretofore.

After various attempts at microorganism control, continuous treatment with copper sulfate was established about 1925 at the Muscoot barrier dam located across the upstream end of Croton Lake. The major yield of the watershed passes this point, which is located about 6 miles above the Croton Lake gatehouse. Copper sulfate dosage has averaged about 0.18 ppm. The condition of microscopic organisms in Croton Lake and the effluent gatehouse since 1920 is shown in Fig. 3. The highly variable nature of the data and numerous complicating factors make it

difficult to evaluate the significance of the information provided therein. It appears that between 1930 and the early 1940's the efficiency of treatment was at its highest. A maximum organism removal of 85–90 per cent is indicated; for the entire period subsequent to 1925 the overall reduction was about 65 per cent. These data do not seem to vary significantly from results obtained in 1920–25. Among the complicating factors are the effects of natural purification, the influence of supplementary treatments and climatic events, and changes in population density on the watershed. It is obvious that a correct interpretation would require further study. In any event, although this procedure of continuous treatment held microorganism growths within certain limits, it did not suffice to keep *Synura*, and at times other significant growths, at desired levels. As a result, additional copper sulfate surface treatment was necessary.

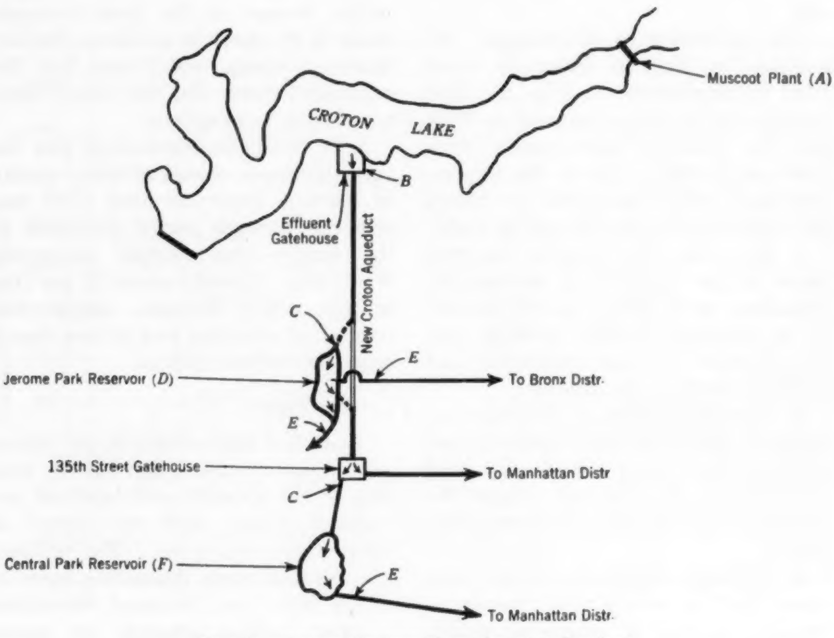

Fig. 4. Croton System Experimental Project

A—*copper sulfate treatment discontinued except as standby;* B—*chlorination and copper sulfate;* C—*auxiliary copper sulfate treatment;* D—*4–5 days' detention;* E—*terminal chlorination;* F—*8 days' detention.*

During 1949 an experimental study of variations in chlorine-copper sulfate treatment was hastily undertaken because of an unprecedented *Synura* infection, in the Croton supply, which resisted the usual control methods. This condition was promoted by prolonged drought and low water levels. Repeated surface treatment with cop-

per sulfate failed to abate the growth, and *Synura* densities of 1,000 standard areal units per milliliter were not uncommon. The following summarizes the results of this activity:

1. When copper sulfate was used alone, 0.24 ppm sufficed to destroy growths containing as high as 2,500 standard areal units per milliliter of *Synura*. Larger dosages were effective but promoted increasingly unpleasant aftertastes. Treatment at the 0.24-ppm level was accompanied by objectionable aftertaste, which even small doses of chlorine accentuated.

2. In combination treatment, 2 ppm chlorine and 0.24 ppm copper sulfate proved optimum, but not more so than 2 ppm of chlorine alone.

3. With 2 ppm of chlorine alone, it was possible to destroy the organism and any aftertaste. The completed reaction occurred within a short period.

4. The experience of the past 4 years (with Croton water) indicates that the chlorine dosage range is critical in the vicinity of 2 ppm. As the dose is lowered, a marked increase in aftertastes is noted, at about 1.8 ppm, and decidedly objectionable tastes are found at 1.4 ppm.

5. Since 1949 superchlorination of the Croton supply at 2 ppm has proved completely successful in controlling *Synura*. It has done away with the uncertainties and inconveniences of surface treatment and facilitated other aspects of taste and odor control.

Full-Scale Experimentation

Unfortunately, microorganism control does not lend itself readily to laboratory scale investigation. Most information of value has been obtained in the field, and in recent years efforts have been directed toward developing techniques adapted to this area of investigation. It is now possible to proceed with large-scale experimentation utilizing the Croton system. The general plan of experiment is shown in Fig. 4. It is hoped that the indicated arrangement will lead to a resolution of numerous imponderables. For example, experience reveals the need for redetermining copper sulfate dosages. The significance of copper sulfate residuals, factors of retention, and secondary treatment effects is among the many matters that remain to be determined with greater precision than may be assumed at present. The experimental arrangement is expected to aid in assessing:

1. Natural purification efficiency during impoundment and the effect of other factors, such as those associated with climatic events. Suspension of treatment at Muscoot will permit observations on these matters.

2. The efficiency of treatment at Croton Lake gatehouse. The data obtained there will include information concerned with variations in chlorine–copper sulfate treatment and the determination of effective dosages for varying organism loads and related conditions.

3. The effects of detention in the Jerome Park and Central Park distribution reservoirs. Obviously time-flow relations are involved.

4. The results obtained with secondary treatment measures at these reservoirs.

5. The influence of terminal-effluent chlorination at these reservoirs.

6. The significance of chlorine and copper sulfate residuals.

7. The correlation of treatment procedures with water quality in the distribution system.

Other Control Methods

Although the department's broadest experience has been with chlorine and copper sulfate, consideration has been given also to other methods and ideas. Fine screening, shallow sand bed filtration, "blackout" with suspensions of insoluble copper compounds, and marginal coagulation are among the ideas entertained and investigated to an extent. Some of these show promise and will be pursued.

At the level of laboratory experimentation, certain types of fine screening may be controlled to achieve efficiencies equal to those obtained in customary copper sulfate treatment, with the added advantage that organisms are removed and do not remain to die and decompose. The present state of technological development in this field, however, is not sufficient to meet the magnitude of water supply requirements. This picture may change in the future. Some of the other ideas indicated a degree of effectiveness that may prove useful, at least in the handling of certain specific situations. It is hoped that the continued investigation of such novel methods may in some measure help in the development of feasible procedures.

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This paper will consider certain aspects of the control of aquatic growths in western reservoirs. It deals primarily with methods, theories, and innovations that are not generally known or readily available in the water works literature. The subject matter is based partially on replies by a representative group of western cities to a questionnaire regarding the problem of aquatic-growth control. It is not certain whether all the methods reported can properly be termed "advances." Suffice it to say that they are relatively new, and only time and experience will prove their merit under different operating conditions. The topics to be considered include methods of copper sulfate application, marginal aquatic-weed control, residual copper sulfate treatment for pondweed and for taste and odor control, a new evaluation of the solubility of copper sulfate in alkaline waters, plankton control with liquid chlorine in large reservoirs, and limnological aspects of copper sulfate treatment.

Information regarding aquatic growths was obtained from Denver, Colo.; the East Bay Municipal Utility Dist., Oakland, Calif.; the Metropolitan Water Dist. of Southern California; Phoenix, Ariz.; Portland, Ore.; Salt Lake City, Utah; San Diego, San Francisco, and Santa Barbara, Calif.; Seattle and Tacoma, Wash.; Tucson, Ariz.; and Los Angeles. Most of the cities followed the conventional methods outlined in the AWWA manual, *Water Quality and Treatment* (*1*).

In general, the problems appear to be more critical in semitropical Southern California than in the Northwest and Rocky Mountain areas. This is undoubtedly due to environmental factors, such as higher water temperatures, longer hours of sunlight, larger impounding reservoirs, and a higher nutrient value in the water supply.

The principal troublemakers among the plankton are reported to be *Anabaena* (*flos aquae* and *circinalis*), *Aphanizomenon, Ceratium, Volvox, Synedra, Chroococcus, Microcystis, Asterionella, Stephanodiscus, Dinobryon, Mougeotia, Sphaerozyga,* and *Cladophora.* The aquatic weeds most commonly encountered include *Chara, Potamogeton* (*panormitanus* and *pectinatus*), *Zannichellia palustris, Vallisneria, Eleocharis, Anacharis,* pond lily, cattail, tule, coontail, and parrot's-feather.

Copper Sulfate Application at San Diego

R. E. Dodson, sanitary engineer at San Diego, reports an unusual method of copper sulfate application for algae control:

The mechanical devices at Lower Otay and San Vicente use copper sulfate "snow," and are mounted on 36-ft landing craft (LCVP) with truck width bow ramps. Each craft can carry about 8,000 lb of copper sulfate. Each feeder consists of a sheet-copper hopper; a bronze rotary feed lock; a small copper receiving hopper with a peripheral jet of flushing water; a 2½-in. bronze ejector with the suction side directly under the receiving hopper; a 100-gpm engine-driven water supply pump, pulling from the lake and discharging through the ejector; a solution discharge manifold; and three discharge nozzles mounted on the stern. Each nozzle is equipped with an adjustable diverter which can be used to flatten the stream (with the wind) or straighten the stream (into the wind).

This feeder produces a mixed solution and suspension of copper sulfate, in quite uniform amounts, over a swath about 50 ft wide. Travel is perpendicular to the wind. In reservoirs with open water and no dangerous rocks, the equipment can cover 1,000 acres in an 8-hr day. Where slow travel is necessary because of navigating difficulties, 500 acres per day is average. [See Fig. 5.]

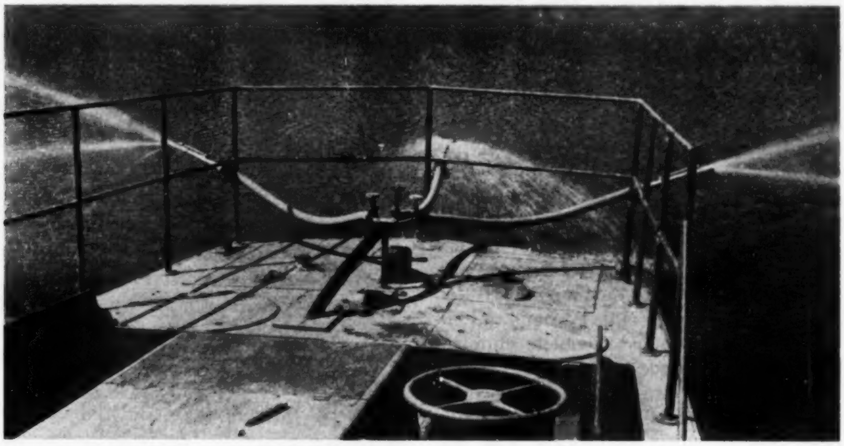

Fig. 5. LCVP-mounted Copper Sulfate Feeder

A mixed solution and suspension of copper sulfate is distributed uniformly over a width of 50 ft.

Control of Tules and Cattails at San Diego

Tule and cattail control, a problem to most water departments, is usually achieved by burning or hand cutting. Dodson reports a variation in standard techniques:

At San Dieguito, the problem was most difficult. The shoreline is on a flat grade and is made up of rich adobe soil. Heavy growths of tules and cattails covered 17 acres around 1 mile of shoreline. After many trials with various weed killers, a formulated petroleum product with wetting and sticking agents was found to be successful at any stage of growth.* This was applied by a scow-mounted sprayer from the water side, and by a truck-mounted sprayer on the shore. Spraying was done as growths matured, but before seeding. Three years of consistent spraying finally reduced the new sprouting to the point where spraying was no longer efficient. Since that time one patrolman spends an occasional day or two cutting new sprouts by hand. This has resulted in almost complete elimination of the shoreline growths.

At San Dieguito, some of the tules were growing in 10–15 ft of water, with only 3–4 ft emerging. This was not enough to give good oil absorption. For these deep-water growths, and also for the outer edges of the original wide bands of growth, a tule cutter was used most effectively. This consists of a self-propelled scow with alfalfa type cutting blades on a leading frame. The frame is lowered into the water, and tule stems can be cut off as much as 3 ft below the surface. It was found that three successive cuttings of the stems under water would kill the entire plant.

We now have a program under way at Murray Reservoir, using the petroleum product previously mentioned on the emerging plants and the tule cutter on deep-water plants. It appears that, in 3 years, we will have almost complete control.

For heavy growths of shoreline tule and cattail, the cost of spraying has been about $15 per acre per application, including labor and materials. During the first year five or six applications were necessary. During the second and third years only three applications per year were necessary.

Los Angeles Methods

The Los Angeles Dept. of Water and Power has 28 open reservoirs, ranging in capacity from 9.4 to 183,500 acre-ft. They are located at elevations varying from 378 to 7,130 ft and are subject to widely diverse climatic and topographic conditions. Consequently, there is a great variety of biological activity, which often produces water of unsatisfactory quality.

The only treatment given the supply before it enters the distribution system is simple chlorination. Thus, quality deficiencies that would ordinarily be taken care of by filtration plants in other cities will be present in the water reaching the consumer and may cause many complaints. The principal problems encountered are related to pondweed growths, plankton activity, and taste and odor control.

The pondweeds, *Potamogeton panormitanus* and *Zannichellia palustris*, flourish in many of the reservoirs. They begin to grow about Mar. 1 in Southern California and may be found anywhere from the shore to depths of 25 ft or more. These weeds act as hosts for microbiological growths, are unsightly in appearance, and attract waterfowl that pollute the supply. During September and October the pondweeds break off and clog outlet screens or pile up on the reservoir banks. They also slough off and, upon

* "Hykil" Weed Oil No. 6, a product of W. T. Cox Co., Santa Ana, Calif., was used.

decomposing, cause tastes and odors and increase the organic load of the water supply.

Residual Copper Sulfate Control

Prior to 1948 many methods of pondweed control had been tried without success. Beginning in that year a series of experiments was conducted, using a constant residual of copper sulfate, which showed that pondweed growths could practically be eliminated, with a marked beneficial effect on plankton growths and taste and odor production. As the details of this investigation have been previously reported (*2*), only current practice will be discussed here.

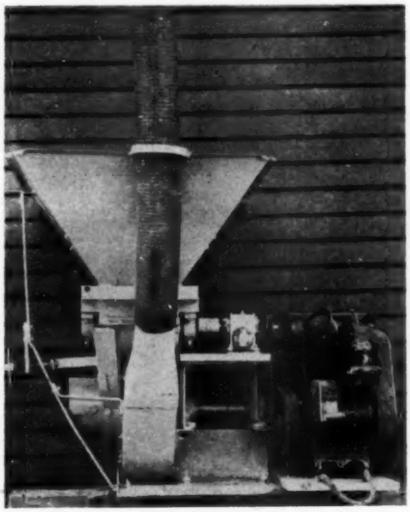

Fig. 6. Blower Type Feeder

This device is employed at Los Angeles to treat top-level reservoir growths with small doses of copper sulfate.

Starting about Mar. 15, a continuous dose of copper sulfate is applied to the Owens Valley Aqueduct supply at the inlet of Dry Canyon Reservoir. The dose is regulated to provide a 0.9–1.0-ppm copper sulfate concentration at the outlet. This concentration is reduced to 0.8 ppm about Jul. 1, and to 0.6 ppm about the middle of August. This dosage is continued until October. After a theoretical retention time of 0.8 days in Dry Canyon Reservoir, the water passes through Upper San Fernando Reservoir (2.6 days) and Lower San Fernando Reservoir (28 days). From Lower San Fernando, the water goes to Stone Canyon Reservoir (50 days) or Lower Franklin Reservoir (6.1 days).

Prior to residual treatment, very heavy growths of pondweed occurred in Dry Canyon, Upper San Fernando, and Lower Franklin reservoirs. Stone Canyon Reservoir, owing to a steep shoreline, had less growth. Lower San Fernando Reservoir was not subject to heavy growths, as it is drawn down about 30 ft each year, making it difficult for the pondweed to get a foothold. All of the reservoirs had plankton growths, and intense earthy-musty tastes and odors developed in the fall in Lower San Fernando, causing widespread complaints throughout the aqueduct distribution system.

Residual copper sulfate treatment has had a profound effect on the system's water quality. Pondweed growths have been reduced to a negligible amount. Growths are limited to an average height of 6 in., instead of the normal 5–15 ft. The areas of growth have contracted appreciably, and often persistent exploring is necessary to find them. As might be expected, the plankton population has declined, and entirely new seasonal growth patterns have developed in the new environment. Contrary to previous experience, the reservoirs above

Dry Canyon now contribute relatively more taste and odor than those which have received residual copper sulfate treatment.

The tastes and odors are apparently the result of complex microbiological decomposition of organic material by actinomycetes or related microorganisms. It is believed that the improvement is due to reduction in the normal food supply of the taste- and odor-producing organisms, and possibly to a direct inhibitory effect on the metabolism of the microorganism responsible.

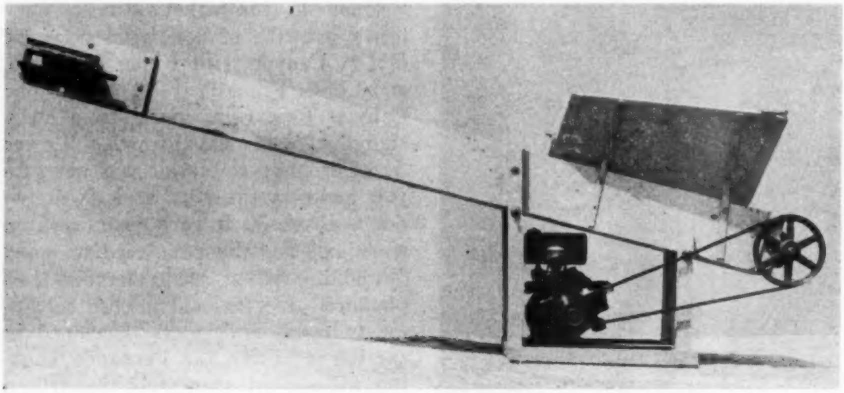

Fig. 7. Belt-Conveyor Feeder

This equipment offers a wide range in chemical feed rate.

Copper Sulfate Treatment

Three different types of equipment are used for copper sulfate application at Los Angeles: a constant-head solution feeder, a blower type of dry copper sulfate distributor, and a dry-feed belt-conveyor distributor (*3*). The solution feeder capacities range from 1,200 to 15,000 lb of copper sulfate. Each unit consists of a redwood storage tank and a water supply source. On opposite sides of the redwood tank, 4 × 6-in. screen boxes are constructed, extending the full depth of the tank. The lower section of each box is perforated with a number of ¼-in. diameter holes. These are large enough to allow the free flow of inlet water and outlet solution but are small enough to prevent the sizable copper sulfate crystals (1 × ½ in.) from clogging the lines. The water supply is furnished by a constant-level tank, and the flow is regulated by an adjustable outlet. All pipe fittings on the copper sulfate solution side are of hard rubber or plastic. The water level in the bottom of the redwood tank is maintained at a depth of about 12 in. The rate of feed is determined by the flow of water from the adjustable-head box through the tank, and the concentration of copper sulfate in the saturated or nearly saturated solution is dependent upon the temperature of the water.

The blower type of copper sulfate distributor has been employed successfully for many years for both surface and depth treatment, but its use is

now limited to the treatment of growths that develop in the top levels of the reservoirs and succumb to small doses of copper sulfate. It is conveniently portable and compact enough to fit into large rowboats, as well as into power boats. The blower operates at 3,000–3,500 rpm and tends to grind the copper sulfate snow into smaller particles. The latter are blown into the air, and wind currents assist in spreading them over the surface of the water (Fig. 6).

The belt conveyor has a number of advantages over the blower type. It allows the operator a very wide range in chemical feed rate—from 1.2 to 200 lb per minute—by a minor adjustment of the feed slot only. It is a light machine, approximately 120 lb in weight, and comes in two sections, making it possible for one operator to transfer it from a truck to a boat, if required. The belt-conveyor feed operates very evenly. It drops the chemical into the propeller wash of the boat, and the distribution is largely independent of weather conditions. The hopper is set very low, 28 in. above the boat deck, so that a minimum of effort is required to fill it. The belt-conveyor trough is adjustable in height and will fit the stern of practically any boat. This machine, after the initial adjustment of chemical feed, demands very little attention from the operator, thus giving him more time for directing the movement of the boat to get the required distance between lanes and attain full coverage of the reservoir. The equipment is especially effective for large dosages. A 46,000-lb treatment has been completed in 8½ hr (Fig. 7 and 8).

Chlorination

The residual copper sulfate treatment is used only in the Owens Valley Aqueduct system. Other sources of water include the Los Angeles River wells and galleries and the Metropolitan Water Dist. supply from the Colorado River. Although all of these sources will support algae growths, the Owens Valley supply is relatively rich in phosphates, and the Los Angeles River is high in nitrates. Recent distribution system changes have caused the intermingling of these sources in many open reservoirs, and growths develop which are not amenable to copper sulfate treatment. The copper will kill some algae, but the surviving species show a marked increase after competition has been eliminated.

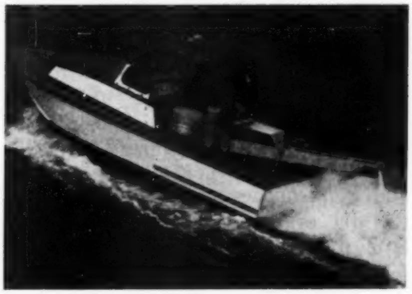

Fig. 8. Motorboat-mounted Feeder

The belt conveyor (shown in Fig. 7) drops the chemical into the propeller wash of the boat.

Silver Lake, a 2,000-acre-ft reservoir that receives a mixed water, has presented one of the principal problems in the system. Prior to improvements in 1953 it had an average depth of 25 ft and was very productive biologically. In past years it had been the policy to avoid copper sulfate treatment until absolutely necessary, as experience had taught that, although the chemical helped temporarily, the more obnoxious, copper-resistant microorganisms would multiply. In deeper

reservoirs, under similar conditions, it is often possible to select satisfactory water from lower levels, but in a shallow reservoir like Silver Lake complaints of "green water" or even "pea soup" are inevitable.

Chlorination was the obvious answer to this problem, but, because of the high chlorine demand of the water and the limited chlorinator capacity (1,000 lb per day), it was not deemed possible to provide a sufficient dosage to correct the condition. During 1952 it was decided to experiment with methods of feeding liquid chlorine directly to the reservoir. On Apr. 3, a heavy growth of *Synedra* was present in Silver Lake. It was planned to employ copper sulfate first and then chlorine, if excessive aftergrowths appeared. The copper sulfate treatment for *Synedra* was successful, but a new growth of spores and *Palmella* developed. By Apr. 24, the pH of the water had risen from 8.02 to 8.90, and oxygen saturation from 100 to 155 per cent; the transparency had dropped from 7.5 to 3 ft. During this period the reservoir was receiving 60 per cent of its water from the Owens Valley Aqueduct and 40 per cent from the Los Angeles River. The nitrate content was 4 ppm, and the dissolved-phosphate concentration 0.14 ppm. Treatment with chlorine was the only recourse in this situation.

In a reservoir as shallow as Silver Lake, the primary problem of liquid-chlorine application is causing the chlorine to become absorbed in the water before reaching the reservoir surface. The controlling factors are the depth and rate at which the chlorine is applied. The maximum depth at which it was practical to treat Silver Lake was 26 ft, and approximately 150 ft of $\frac{1}{4}$-in. black iron pipe was needed to reach the proper elevation along the sloping bottom. A small header with four outlets about 4 ft apart was used at the end of the pipe. A previous experiment had shown that about 200 lb an hour could be fed at this depth with almost 100 per cent gas absorption.

The rate of flow was controlled by a silver orifice inserted between the open cylinder valve and the flexible $\frac{1}{4}$-in. copper tube that connected the $\frac{1}{4}$-in. pipe to the chlorine cylinder. The orifice was cleaned every hour, and 11–12-hr runs were obtained. Only slight chlorine odors were noted on shore. Treatment was continued until residuals were found throughout the entire reservoir. Chlorine was applied at three different locations, $7\frac{1}{3}$ tons being used. This means of direct chlorine injection was successful and is currently used for emergency treatment when normal chlorination equipment cannot provide a sufficient dosage.

The flexibility of this method enables it to be varied to meet the physical, chemical, and limnological conditions prevalent. The primary factors to be considered are the depth and stratification of the reservoir, the circulation pattern at the time of treatment, and the chlorine demand of the water. It has been found that, by changing the diameter of the silver orifice, the rate of chlorine application can be varied from 100 to 700 lb per hour, and reservoirs can be treated while in service if the circulation pattern will permit an adequate time interval before the treated water enters distribution. If necessary, dechlorination can be carried out at the reservoir outlet.

Many interesting applications are possible with this technique. For example, in the fall of 1953, 2,000 lb of chlorine was injected in 3 hr in and below the thermocline at Lower Holly-

wood Reservoir. This was an experimental treatment for the control of taste and odor production at the hypolimnion or bottom stagnation zone. The thermocline was 110 ft below the surface at the time, and only 8 ft below the lowest tower gate. Although the chlorine concentration built up to 15 ppm within the stratified area, no trouble was experienced with excessive chlorine in the distribution system.

In applying liquid chlorine, the feed line must be of such physical character that the point of pressure release will be in the water and not at the chlorine cylinder. Otherwise, the heat supply required for rapid vaporization will not be adequate, and the cylinder will freeze and be unable to deliver the needed amount of chlorine. Furthermore the rate of application must be suited to the particular limnological conditions, so that the chlorine will be completely absorbed by the water and not become a hazard to the neighborhood.

Effectiveness of Copper Sulfate Residuals

It was noted early in the residual experiments that copper sulfate added at Dry Canyon Reservoir had a marked effect on the biology in the chain of reservoirs which did not receive the copper for a matter of weeks or even months. This observation does not strictly conform to most statements on the subject in the literature. For example, *Water Quality and Treatment* (*1*) says:

> With respect to copper sulfate, it may be pointed out that when that chemical is left free in water, it reacts with calcium bicarbonate to form calcium sulfate and basic copper carbonate. The basic copper carbonate may then be decomposed into copper hydrate and carbonic acid. Both the carbonate and hydrate have very low solubilities; and in a hard water the carbonate may be almost instantly precipitated, the subsequent decomposition into the hydrate requiring a longer period.
>
> . . . insoluble copper carbonate is precipitated from the water to which it is applied—immediately in the case of most waters; more slowly, but still long before delivery, in a very soft water.

As the Owens Valley Aqueduct supply has an average alkalinity of 115 ppm, a hardness of 84 ppm, and a pH of 8.5, it might be expected that the copper would precipitate rather rapidly as a basic carbonate. Actual experiences during the past 4 years indicate that much of the copper remains in the water for many weeks. It has not been determined whether copper is present in an ionic or nonionic form, but there can be little doubt that the toxic effect of copper on algae and pondweed lasts longer than is commonly believed. It has been found that total copper sulfate residuals as low as 0.2 ppm, which have "aged" for 2 months, will change the character of the plankton population and have an inhibitory effect on the growth and reproduction of pondweed. This is obviously a fertile field for further investigation.

Limnological Considerations

General information on the limnology of reservoirs and its influence on water quality is readily available in the literature (*4*) and will not be discussed in detail here. Factors such as the depth of the water, location of the thermocline, air temperature, wind velocity, length of wind sweep across the water surface, radiant energy, and size and shape of the reservoir should always be taken into consideration in planning treatment. One factor that seems to

be overlooked frequently is the variable relationship between the calculated dosage and the volume of water to be treated. The conventional procedure is to base the dosage on the entire volume of the reservoir as determined by reference to surface elevation–volume graphs prepared from contour maps or soundings. This procedure is valid only when the entire volume of water in the reservoir is in vertical circulation.

In Southern California, for example, most reservoirs are in complete circulation only between November and April. During the remainder of the year they are in varying degrees of stratification, and the volume of water in the epilimnion, or upper zone of circulation, may vary considerably. For instance, assume that a specified dosage of copper sulfate will result in a concentration of 0.3 ppm during January and that in August the epilimnion contains only 50 per cent of the water in the reservoir. Under these conditions, the concentration would actually be 0.6 ppm for the treated water, so that twice as much copper sulfate would have been used as was necessary.

Another factor not always considered is the character of the circulation within the epilimnion itself. The morning sun will warm up the top few feet of a reservoir surface and temporarily interrupt the normal vertical circulation pattern. When the surface water cools off in the evening, the vertical circulation will be accelerated. It thus follows that morning treatment is best for surface growths where the copper should be retained in the upper layers, and afternoon or even night treatments are best where the entire epilimnion must be treated.

Acknowledgment

The author wishes to thank the following water department engineers for their cooperation in surveying western practice in the control of aquatic growths: George J. Turre, Denver, Colo.; Ben S. Morrow, Portland, Ore.; Roy E. Dodson, San Diego, Calif.; A. G. Knight, Salt Lake City, Utah; Harry W. Tracy, San Francisco, Calif.; Ralph Fowler, Seattle, Wash.; W. A. Kunigk, Tacoma, Wash.; T. V. Berry, Vancouver, B.C. (Greater Vancouver Water Dist.); Blair I. Burnson, Oakland, Calif. (East Bay Municipal Utility Dist.); Dario Travaini, Phoenix, Ariz.; Clyde Richardson, Santa Barbara, Calif.; Lee Streicher (Metropolitan Water Dist. of Southern California); and Phil. J. Marlin Jr., Tucson, Ariz.

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Water Rights Law in Michigan

Joint Discussion

A joint discussion presented on Sep. 15, 1954, at the Michigan Section Meeting, Muskegon, Mich.

Causes of Legal Problems—*Norman F. Billings*

A paper presented by Norman F. Billings, Chief, Hydrology Div., State Water Resources Com., Lansing, Mich.

SEVERAL factors set water supplies apart from other resources and lay a foundation for unique legal problems. One is the great and complex scope of water resource use. The management and production of most resources are carried on by specialized enterprise. Water, however, is dealt with directly by interests that are representative of the entire citizenry and economy, are exceedingly numerous and universally distributed, and are generally uncoordinated with one another. Stated more simply, everyone makes use of the resource, often directly and usually without much reference to other users.

Another factor important from the legal standpoint is the peculiar nature and behavior of this resource. It is, first of all, highly dynamic—always moving, always changing, varying radically and unpredictably from season to season. It responds quickly to artificial and natural influences and, in such response, recognizes no property lines. Much of its behavior is very obscure, especially when it is underground. Thus, what is done by one interest at one location may have a pronounced effect at other places and on other parties. Yet the latter are often either unaware that a change has occurred or ignorant of what caused it.

A third major distinction between water and other resources is the public attitude toward it. Lifelong acquaintance with water, its apparent abundance, and its regular use tend to cause the individual to take it for granted. This attitude leads to a contempt for research and study while the situation seems satisfactory and to unsound solutions when problems arise. To put it bluntly, few people take much interest in water till trouble arises, and then everyone becomes an expert. A few examples will illustrate the point of these observations.

Ground Water Levels

The production of water from any well, no matter how slight the flow, causes some lowering of the ground water level in the immediate vicinity. If the producing formation is nonartesian, the effect may be quite local, but even such aquifers can be lowered enough by municipal pumping to cause trouble, as Ann Arbor (see page 1164) will bear witness. There the injury was to some dug wells and to muck lands in which high water levels were important to crop production. Where

the formation is artesian, the effect may extend for considerable distances. An artesian formation is simply one which is overlain by a relatively watertight stratum like clay or shale and which is full of water under such hydrostatic pressure that it will rise in wells to an elevation higher than the bottom of the watertight stratum. Because water is relatively incompressible and the confining strata of an artesian formation are relatively rigid, pressure changes are transmitted through the formation rapidly and far. Other things being equal, the greater the pumpage, the greater the lowering of the water level.

Municipal water supply wells often result in heavy drawdown. In a few fortunate towns, drawdown may be measured in inches, but in most city wells, drawdown of several feet—sometimes tens of feet—occurs, and the area significantly affected extends over hundreds of acres or even square miles. Recent years have seen great residential development just outside the corporate limits and beyond the reach of municipal water service. There, all dwellings have their own wells, many of which are as shallow as possible. Whether deep or shallow, suction pumps are utilized wherever they can be. Hence, these wells are very sensitive to water level changes. If that level falls below the suction limit or, in any event, below the top of the well screen, the well simply quits producing, to the understandable consternation of the well owner—or, more likely, of his wife. It is very seldom that such a problem develops overnight. Instead, the water level declines slowly in intermittent steps as municipal (and other) pumpage increases through the years, coming to public attention only when wells begin failing.

As long as a city is able to keep its wells far inside the area served by the municipal supply, the drawdown effect at suburban wells may be slight. As is well known, however, considerable search is often necessary to find underground conditions suitable for well construction. Also, high-capacity wells cannot be located too close to each other without reduction in yield. For these two reasons, as well as for purposes of isolation, it is sometimes necessary to construct municipal wells outside the corporate limits. At Hart, Mich., for instance, all of the wells are out of town, but the underground formations that supply the municipal and many of the suburban private wells are under enough pressure so that normally the wells all flow. In order to supply its customers' needs, however, the city has had to take more than the natural flow and to install pumps. During recent summers several private owners have complained that flow from their wells has been reduced or stopped, at least temporarily.

Before Flint, Mich., decided upon the construction of a surface reservoir, it cooperated with the US Geological Survey in a study of ground water prospects. Although a substantial supply was found, pumping tests showed that, if this source was utilized for municipal supply, water levels in several hundred private wells would be lowered enough to require the installation of deep well pumps.

The causes of well failure are not limited to the pumping of other wells. Every flowing well supplied by a given formation tends to reduce the pressure at other wells. A lowering of the pressure surface (the height to which enclosed waters will rise) is produced by a flowing well just as it is by a pumped well, and the greater the flow, the

greater the pressure drop. Sometimes the flow breaks through the watertight stratum that confines the artesian water outside the casing. Such an event occurred at Indian River, Mich., several years ago during the repair of a private well. Flows of many neighboring wells dropped immediately, and the pressure was no longer adequate to lift water to second-story bathrooms. The opening was sealed, after much trouble, by drilling a second well that was pumped at a rate high enough to stop flow through the breach. Cement was then injected into the breach and allowed to harden.

In summary, any removal of water from an artesian formation will be followed by the lowering of levels throughout the area. The quantities removed by municipal wells are often great enough to affect other wells hundreds and sometimes thousands of feet away. Furthermore, no artesian formation capable of supporting municipal wells is totally sealed off from shallow or nonartesian ground waters. Somewhere, each artesian formation is in contact with an area whose ground waters, lakes, and streams recharge or replenish it. The net result of tapping the formation is a lowering of ground water and lake levels or of stream flow in the recharge area.

Ground Water Pollution

Soluble wastes placed in or on the ground have the same opportunity as rain and snow to percolate through the soil into subterranean water reservoirs. If the point at which the wastes enter the reservoir is within the area of drawdown caused by a well, they will eventually enter the well. In Michigan, such pollution of city wells has occurred at Edmore (salt), where the source was attributed to the wastes of nearby pickle-brining stations; at Alma (phenol), from the waste-burning pit of an oil refinery; at Douglas and Grandville (chromates), from plating plants; and at Lansing (picric acid), from a chemical plant. In most of these instances, the city has been involved only as a recipient of injury. At Grandville, however, the immediate source of pollution was believed to be a city sewer that carried chromium-bearing wastes from the plating plant. And at Bronson, Mich., where disposal of chromium wastes into a shallow pit is now in litigation, both the pit and the sewer carrying the waste to it are city owned.

A new source of ground water pollution is air-conditioning and other temperature control systems that use water. There is a growing tendency, inspired by the desire both to maintain ground water levels and to avoid high sewer taxes, to dispose of the warmed waters underground. Proof of the deleterious effect of this practice is lacking in Michigan, but, on Long Island, N.Y., it has caused the temperature of ground water supplies to rise as much as 20°F. Where open cooling systems are used, there may also be the danger of bacteriological or even chemical contamination.

Stream Flow

The widespread and complex interrelationship among users finds even greater expression in surface waters than in ground waters. Although the flow of streams is visible, in contrast to the movement of ground water, it is much more rapid and varies quantitatively to a much greater degree. Stream flow is, accordingly, difficult to evaluate. The field of conflict among users is even wider than with ground water, because surface water serves

not only for supply but for recreation, power development, navigation, and waste disposal. Moreover, the geographic area of interrelated problems is often much larger.

The extent to which stream flow varies depends not only on the weather but also, to a very great degree, on the geology of the drainage area. The Manistee, Boardman, and other Michigan streams whose drainage areas contain much outwash plain or sandy moraine are very stable. Streams like the Cass and Clinton, the watersheds of which contain large percentages of lake plain and till plain, are much more flashy. In July 1952 low flow in the Rogue River, at Rockford, Mich., was 70 cfs, while in the Cass River, at Frankenmuth, Mich., it was only 63 cfs. Yet, above the places mentioned, the Cass drains a watershed nearly four times as large as that of the Rogue. During a dry spell in August 1944 the Cass declined to a minimum daily flow of 1.5 cfs, and the average for the month was only 20 cfs—from 848 sq miles of drainage area. It may be assumed that the 20-cfs flow was natural, but the 1.5-cfs minimum was due to the operation of the village-owned dam. On smaller streams that drain areas of similar geology, the flow may drop to much lower rates. The periods of low flow often coincide with times of greatest municipal demand, as well as with the maximum need for irrigation—a relatively new type of water use in Michigan. Most irrigation systems use water at rates of hundreds of gallons per minute, which means that, even where a medium-size stream is involved, they can affect or be affected by municipal pumpage.

Michigan rivers ordinarily tend to increase in size downstream. During drought periods, however, the less stable of them may flow for miles without an increase and may even lose water through evaporation and seepage. An example is the Clam River, with its headwaters in Lake Cadillac. Several checks have shown a progressive lessening of flow for some miles below the lake, the loss being attributed to seepage. Other streams undoubtedly lose significant portions of their flow to stream bank and emergent vegetation. It is, therefore, not safe to shut off a dam entirely and assume that the stream below will quickly pick up enough flow for downstream needs.

The kind of stream that tends to fail during drought is sensitive also to flood. Many of the smaller dams in Michigan have inadequate flood water spillways. Visual inspection indicates that some dams are deficient in other structural respects. Generally, the smaller a stream of a given type, the greater its maximum runoff per unit of drainage basin—20 cfs per square mile of drainage area has been recorded for Michigan streams with drainage areas greater than 500 sq miles.

Stream Pollution

Streams may be polluted in the following ways:

1. By disease organisms, the most usual source of which is raw sewage. Such pollution can endanger health if the water is used for fishing, bathing, or domestic supply. It is sometimes said that a stream purifies itself in flowing a certain distance. Certainly, disease bacteria cannot live forever in a foreign environment. The factors that sustain or damage bacterial life vary greatly from stream to stream and time to time, however, and no dependence should be placed on an arbitrary "purifying" distance.

2. By oxygen-demanding material, which, through decomposition or chemical action, will remove enough of this element from the water to injure fish or fish food. Sewage is a major source of such pollution.

3. By taste-producing substances like phenol.

4. By poisons, such as hexavalent chromium and cyanide.

5. By common chemicals like chlorides and sulfates whose effect is to render water less usable for supply or to increase treatment costs.

6. By oils and greases, which can adversely affect fish and fish food, waterfowl, and small-boat navigation.

7. By solids, such as silt and fiber, which can clog the channel and, in time of flood, be deposited on flood plain lands.

Lake Levels

Some municipal water supplies are taken from lakes, either inside or outside the corporate limits. Where the lake is large and the pumpage is small, its effect is not likely to be significant. For example, 3 months' pumpage at 1 mgd is equal to about 30 in. on a 100-acre lake or 3 in. on a 1,000-acre lake. On lakes that normally fall to summer levels too low to suit riparian users, even a few inches of additional lowering can cause trouble. Waterfront development is often carried on so close to the water's edge that high levels are equally objectionable, a situation that can hamper attempts to store water in times of plenty. Any reservoir fluctuation tends to meet with increasing public resistance, especially where waterside development is permitted.

Conclusion

Almost every type of water supply source, except possibly the Great Lakes, is subject to factors that can cause legal problems for the user. Many types of problems can involve the municipal user as either plaintiff or defendant. As water itself is dynamic and its uses are constantly changing with the times, it is seldom possible to provide for every contingency. Nevertheless, it should always be borne in mind that water supply developments may affect a broad area, and considerable foresight should be employed in their planning.

Legal Principles and Decisions—*Florence Clement Booth*

A paper presented by Florence Clement Booth, Asst. Atty. Gen., Lansing, Mich.

Until recent years Michigan gave little thought to the protection and preservation of its vital water resources. At present, from a legislative point of view, the state's primary concern in this field is not with the sufficiency of the supply but with the control of pollution. The quality of water in lakes and streams must be protected in the interest of the public health and welfare. Problems relating to sources of water supplies for growing municipal and industrial needs and fair and equitable provisions for the most beneficial use of water are still matters of study and research.

In 1949, in an amendment to the old Stream Control Act, the legislature delegated to the Michigan Water Resources Commission the duty to "pro-

tect and conserve the water resources of the state," as well as to control the pollution thereof. The commission was empowered "to make or cause to be made surveys, studies, and investigations of the uses of waters of the state, both surface and underground, and to cooperate with other governments, governmental units, and agencies thereof" in making such investigations and in other "matters concerning the water resources of the state, including but not limited to flood control and beach erosion control" (*1*). Emphasis is thus placed upon problems caused by excess water rather than by water shortages.

In an earlier statute (*2*), governing the incorporation of home rule cities, each city so incorporated was given the right to provide in its charter: "For the use, control, and regulation of streams, waters, and watercourses within its boundaries, but not so as to conflict with the law or action thereunder where a navigable stream is bridged or dammed; or with riparian or littoral rights without their corporate limits. . . ."

There are several Michigan laws relating to the incorporation and powers of companies supplying water to municipalities. Another act (*3*), relating to the construction and maintenance of bridges, requires a permit for artificially altering the stage of a stream or widening or deepening the channel of any watercourse, except drains established by public authority. Other statutes provide for the establishment and maintenance of inland lake levels.

Schenk Case

The Michigan law relating to water rights will not be found in legislative enactments, but in the comparatively few decisions of the state supreme court. One of the landmark cases on water rights is *Schenk* v. *City of Ann Arbor* (*4*), which involved a question of the legal right of Ann Arbor to pump water for its municipal supply in such a manner and in such quantities as might injure wells on nearby properties. In 1915 the city had constructed a 16-ft test well in acreage purchased by it a short distance outside of the city limits. For nearly 2 months approximately 3.7 mgd had been pumped. Nearby landowners, claiming that the test pumping had affected their wells adversely, brought suit to restrain the city from proceeding with its program of drawing about 4 mgd for its municipal supply.

The court found that the underground waters involved were "percolating waters," a term which, in the legal sense, means underground waters that have no definite channel or course. The fact that such waters may come together underground at certain points in rivulets does not destroy their character as "percolating waters." For the purpose of determining legal rights, "percolating waters" are distinguished from "subterranean streams." Unless it is known or ascertainable from surface indications or by other means that the underground water flows in a definite channel and so is an "underground stream," the courts presume it to be "percolating water." The distinction between "percolating waters" and "subterranean streams" is significant because legal rights with respect thereto are predicated upon different theories of law.*

* In effect, the "percolating water" of the Michigan courts is what is commonly termed "ground water." Rights and liabilities with respect to a "subterranean stream," if it existed, would be governed, as far as practicable, by the rules of law applicable to surface watercourses. No underground body of water, however, has yet been declared a "subterranean stream" by Michigan courts.

A material fact in the Schenk case is that the city did not contemplate using only the volume of water which would flow naturally from its wells. The natural flow was to be augmented artificially by pumps, which would draw ground water from surrounding lands over a considerable area. Also, it was deemed to be material that the city did not intend to use the water for the benefit of the land from which it was taken or for its own benefit as a landowner, but planned to pipe the water away from the land, to sell some of it, and to use some of it for municipal purposes. The court held that the right of a landowner to take percolating—that is, ground—water to the injury or detriment of other landowners is a "qualified right."

The court then proceeded to discuss early English and American cases with reference to the rights of a landowner to take such waters from his land. Early cases enunciated the doctrine that the landowner had absolute ownership of underground waters. This doctrine was based upon the principle which gives to the owner of the land all that lies beneath the surface, whatever its nature. Under this early principle, the owner of the land could sink wells in it and use the ground water in any way he chose, regardless of the effect upon his neighbors' wells and even though he was actuated by malice. A neighbor injured by such withdrawal of water was without legal redress for the damages suffered. Because the right to percolating waters is treated as a property right, it could not be taken away except through the exercise of the right of eminent domain or of the police power in the interest of the public welfare.

With increasing use of ground water, the rule of absolute ownership was seriously questioned. The courts recognized the real problem but, because they hesitated to overrule the early decision expressly, they said that the rule was not being changed but "enlarged and extended" to meet new conditions. This so-called enlargement led to what is known as the rule of "reasonable use":

> Each owner of soil lying in a belt which becomes saturated with percolating water is entitled to a reasonable use thereof on his own land, notwithstanding such reasonable use may interfere with water percolating in his neighbor's soil; but he has no right to injure his neighbors by an unreasonable diversion of the water percolating in the belt for the purpose of sale or carriage to distant lands.

In the Schenk case, the Michigan supreme court announced its adherence to this doctrine. It found that, if Ann Arbor, in taking water away from the land, for sale and municipal purposes, damaged wells on adjacent land, it thereby usurped the water rights of the adjacent landowners so injured. The court also held that the city, as a municipal corporation seeking water for its inhabitants, was in a private business and was a private owner of the land involved; and that, although it was imperative for the people of Ann Arbor to have water, it was not imperative that they secure it at the expense of other private landowners.

Despite its finding that the plaintiff's water rights had been interfered with contrary to law, the court did not grant the injunction prayed for in plaintiff's bill of complaint. The reason given was that the court refused to assume that the city would so carry out its water supply program as to injure nearby wells. Although not granting the injunctive relief sought, the court's decree stated that, if the city's pumping operations were of such propor-

tions as to place the plaintiff's wells in imminent danger of injury, another suit to restrain such action might be commenced. The decree did provide damages for injury already suffered from the test well.

On the question of the type of relief to be afforded one who complains of an unreasonable use of ground water by another, the dissenting opinion of Judge Brooke in the Schenk case is of interest. He said:

> I think that the defendant should either be permanently enjoined from proceeding with the contemplated enterprise, at this time, and upon the testimony in this record, or that injunctive relief should be denied, and the decree of the court below affirmed, by the terms of which plaintiff was awarded damages for such injury as has already occurred and his right to recover for future damages preserved.

The principle of law established in the Schenk case may be summarized as follows: although a landowner has a property right to sink wells on his own land and use ground water in any way he chooses even if he dries up his neighbors' wells, this property right is qualified by the rule of reasonable use. This is known as the "American" or "reasonable use" rule or as the doctrine of "correlative rights." Under this rule or doctrine, a landowner may consume, on his land, as much of the underground waters as is necessary for agriculture, manufacturing, irrigation, or other purposes, even though the effect of such use may be to divert or interfere with the ground waters of neighboring land. The withdrawal of such waters for sale or distribution and use away from the land, however, may be unreasonable if it interferes with a reasonable use of waters by adjacent landowners. Whether the use of the water is reasonable under all of the circumstances involved must be determined from the facts in each case. Of course, only in the event of injury, actual or threatened, can the complaint of a landowner regarding the use made of ground waters by his neighbor be heard.

St. Louis Case

In 1922 the Michigan supreme court decided the case of *Bernard* v. *City of St. Louis* (5), citing with approval the ruling in the Schenk case. In the St. Louis case, the decision was that the city should not deprive the plaintiffs of an adequate supply of water for their reasonable use without compensating them, provided that the plaintiffs did not permit water waste. The court's opinion is not too helpful as a precedent, for it is not clear whether it was intended to change the generally accepted rule of reasonable use of ground waters. Ordinarily, it has been held that a landowner cannot recover for injuries to his wells or springs resulting from a lawful exercise of water rights by an adjoining owner. The author interprets the Schenk case to have so held. In other words, applying the rule of the Schenk case, unless St. Louis was making an unreasonable use of its ground waters, it was not liable for damages for any resulting injury to the plaintiffs' spring. Yet the court did not specifically find that the city's use was unreasonable. Rather, it stated:

> We are not satisfied, however, that, if the city makes a reasonable use of the percolating waters and the plaintiffs do not permit [water] waste, . . . there will not, nearly all of the time, be an ample supply for the needs of both. If there should not be [an ample supply for both] then the plaintiffs should not be deprived of a supply of water sufficient for their reasonable use without compensation, nor

should they be required to install new machinery without compensation.

Possibly the court was influenced by the fact that the plaintiffs' spring was a flowing well which had been in use for the same purpose for more than 50 years. Whether the court was thinking in terms of water rights being gained by prescription (long, undisputed use) does not appear affirmatively, but such is the inference. The court did not seem to give any weight to the fact, urged by the defendant, that the plaintiffs' well, a mineral spring with claimed curative properties, was used commercially as part of a hotel.

As mentioned before, the type of relief that will be granted an owner whose water rights have been interfered with may be of as much significance as the existence of those rights. In the St. Louis case, as in the Schenk case, the court considered the matter at length and refused injunctive relief at that time, on the ground that the city was not then interfering with the plaintiffs' use of the spring. The following rule of law was quoted:

> In 27 R.C.L. at page 1182, it is said: Injunctions involving rights to percolating waters should . . . be granted, if at all, only upon the clearest showing that there is immediate danger of irreparable and substantial injury and that the diversion complained of is the real cause. Injunctions involving rights to percolating waters will be refused if the complainant has stood by while the development was made for public use and has suffered it to proceed at large expenditure to successful operation, having reasonable cause to believe it would affect his own water supply; and if a party makes no use of the water on his own land, or elsewhere, he should not be allowed to enjoin its use by another who draws it out or intercepts it, or to whom it may go by percolation, although perhaps he may have the right to a decree settling his right to use it when necessary on his own land, if a proper case is made. When the rights of the public are involved in a suit to enjoin the abstraction of subterranean waters for use at a distance, and the court can arrive in terms of money at the loss which local landowners have sustained, an absolute injunction will not be granted, but the proceeding will be regarded as one to secure compensation to the local owners for their injury.

Surface Water Rights

In the determination of water rights to surface streams and bodies of water, two basic doctrines of law have been applied in the United States. In some states, water rights belong solely to riparian owners. In others, the doctrine of prior appropriation prevails. A few states use both theories, appropriation being applicable to public waters and riparian rights prevailing in private waters.

The term "appropriation" refers to a means of acquiring a vested and continuing right to take a definite quantity of water from a natural watercourse or other body of water. Generally, the doctrine of prior appropriation prevails in arid or semiarid regions in which the doctrine of riparian rights has been found unsuited to conditions. The appropriation doctrine has been gaining in favor as a practical device for meeting water needs in jurisdictions where water is in short supply and is necessary for so-called artificial purposes at points removed from the sources of surface streams. This doctrine has an additional advantage in the security it provides to the appropriator with regard to the quantity of water to which he is exclusively entitled under usual circumstances.

In Michigan and a majority of the other states, water rights in natural watercourses belong to the riparian

owners. Such ownership carries with it the right to the flow of the stream in its natural course and in its natural condition with respect to both volume and purity, except as affected by the reasonable use of other proprietors. Also included is the right of access to and the use of the stream or body of water. Theoretically, all riparian owners have equal rights to use a stream with all its natural variations of flow. The main objection to the riparian doctrine is its failure to emphasize or provide for the most beneficial use and for conservation.

Many of the Michigan cases involving the exercise of riparian rights relate to logging or mill operations, nonconsumptive uses of water. Although these cases are important historically in any analysis of Michigan water rights law, utility operators may be more interested in a case involving the disputed right of a municipality to take water from a lake. In *Stock* v. *City of Hillsdale* (*6*), a lower riparian owner on the St. Joseph River sought to enjoin Hillsdale from increasing the capacity of its water plant or from laying more pipe into Lake Bawbeese and diverting water from the river to the injury of the plaintiff's dams and millraces. The court held that the city did not have the right, as an upper riparian owner, to pump water out of the lake for the use of citizens generally and for supplying manufacturing establishments within the city limits if properties of lower riparian owners were seriously damaged thereby.

Another issue in this case involved the change in water rights that resulted because the plaintiff waited so long to take action against the city. The court held that, as the right to take water is a property right, it could be acquired by the city by prescription. In other words, the city, having taken water openly and adversely to the plaintiff's rights and with his knowledge for a period of 15 years, had acquired a property right to do so. Acquisition of water rights by prescription is governed by the same rules of law as is title to other real property.

The prescriptive water rights acquired by Hillsdale were, however, limited to the amount that it had taken for the prescriptive period. Thus, after the 15-year prescriptive period, the plaintiff lost the right to complain about the future diversion of this amount of water, but the threatened increase could be enjoined. The plaintiff was allowed the actual damages suffered by him during the 6-year period immediately preceding the commencement of the suit. Damages were established with regard to the actual loss to the plaintiff and were not based on the sale price received by the city for the water diverted. It appears that a landowner whose rights to surface water have been taken illegally has to prove, not only the illegal act, but also his right to injunctive relief to prevent a continuance of the loss of water, as well as the fact that he has suffered actual damage.

The extent of the right of a riparian owner to take water from a stream is determined with reference to the like right of other riparian owners. In dealing with riparian rights to surface streams, the question of reasonable use arises, and consideration must be given to the facts of the particular situation existing, in much the same way as for ground waters. Again a qualified right is involved.

In the case of *Mastenbrook* v. *Alger* (*7*), the court found that the use of water from a stream for irrigation purposes was unreasonable as it interfered with the right of the lower riparian owner to use the stream for domestic

purposes and stock watering. The defendant was enjoined from using the water for other than ordinary domestic purposes because the flow was barely sufficient to supply water to the riparian owners along the stream for their natural wants.

Generally speaking, it may be said that a riparian owner has such rights to the waters of a stream as are necessary to the use and enjoyment of his abutting property, subject, however, to the correlative rights of other riparian owners. In the exercise of his rights, a riparian owner must consider and not injure other riparian owners in the enjoyment of their rights. This qualification does not mean, however, that a riparian proprietor may not in some degree affect the volume and purity of the water of a stream. This principle was applied by the Michigan supreme court in *People* v. *Hulbert* (*8*). Battle Creek had decided to take water from Lake Goguac for its municipal supply, claiming the right to do so as a riparian owner. The city took the position that other riparian proprietors on the lake must do nothing that would have a tendency to pollute the water. The respondent, a riparian owner, claimed the right to exercise his common-law riparian rights of bathing, swimming, washing sheep, watering cattle, running a water wheel for a mill, and so forth. In order to test the rights involved, the respondent, after notifying the Battle Creek Board of Public Works, went swimming in the water flowing over his land. He was arrested upon the criminal charge of polluting a source of public water supply. The court phrased the question thus presented as follows:

> Will the fact that a lower riparian proprietor decides to use the water of the stream or lake for drinking and cooking purposes make a reasonable use of the water by the upper riparian owners for the purposes of watering cattle and bathing . . . unlawful because to do so has a tendency to make the water less desirable for drinking and cooking purposes?

After it had reviewed at length the early basic cases in this and other jurisdictions with reference to riparian rights, the court said:

> It is very clear from these cases that the lower proprietor has no superior right to the upper one, and may not say to him that, because the lower proprietor wants to use the water for drinking purposes only, the upper proprietor may not use the water for any other purpose. Each proprietor has an equal right to the use of the stream for the ordinary purposes of the house and farm, even though such use may in some degree lessen the volume of the stream, or affect the purity of the water. . . . It is not believed a case can be found where, out of deference to the rights of the lower riparian proprietor, it is made unlawful for the upper proprietor to make such reasonable and ordinary use of water passing over his land as was made by the respondent in this case.

Thus, it may be said that, as between different proprietors on the same stream, the right of each qualifies the other, and the question always is, not merely whether the lower proprietor suffers damage by the use of the water above him, nor whether the quantity flowing is diminished by the use, but also whether, under all the circumstances of the case, the use of the water by one owner is reasonable and consistent with a corresponding enjoyment of his right by the other.

Diffused Surface Waters

The preceding discussion of surface waters has considered waters running or contained in definite channels or

areas. Questions arise also in regard to diffused surface waters. Such problems are more likely to relate to drainage rather than rights to take water. Two basic principles have been applied in this matter. In some jurisdictions, the "common enemy" doctrine prevails, and in others the civil law rule (from the Code Napoleon) is applied. Under the former rule, the landowner is entitled to treat diffused surface waters as a "common enemy" and to deal with them in any way he pleases, so long as he does not unduly collect, concentrate, and discharge them upon his neighbor's land in unnatural or unusual quantities.

Under the civil law rule, a landowner is entitled to have diffused surface waters go down to and pass over his neighbor's lands without interruption. In a sense, the upper landowner has an easement over his neighbor's land for the passage of such waters. In turn, the lower proprietor may insist that the waters are not unduly collected and discharged over his land contrary to natural drainage.

The law in Michigan falls into the second category. In *Fenmode* v. *Aetna Casualty and Surety Co.* (*9*), diffused surface waters are defined as "waters on the surface of the ground, usually created by rain or snow, which are of a casual or vagrant character, following no definite course and having no substantial or permanent existence." In *Crane* v. *Valley Land Co.* (*10*), the court stated:

> The law is well settled in this state and elsewhere that the natural flowage of [diffused] surface water from an upper estate is a servitude which the owner of the lower estate must bear, and he cannot hold it back by dikes or dam its natural channels of drainage to the injury of the owner of the upper estate.
>
> In turn, the upper landowner cannot lawfully concentrate surface water and pour it, by means of artificial ditches and drains, in unusual quantities and velocity, upon the land of an adjacent proprietor [*Ruehs* v. *Schantz* (*11*)].

This brief discussion has touched upon only a few of the principles of law involved in some of the problems that have arisen in connection with the determination of water rights. From what has been said one could not attempt to reach any conclusions as to how the courts might resolve a conflict of interests in any particular case. It is hoped, however, that an understanding of judicial thinking has been gained which may serve as a guide in future studies of water law and in any consideration of the need for specific legislative action to establish a modern water policy for Michigan.

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Water Works Problems in a Rapidly Expanding Community

By Glenn E. Hands

A paper presented on Sep. 22, 1953, at the Rocky Mountain Section Meeting, Santa Fe, N.M., by Glenn E. Hands, Prin. Engr., Burns & McDonnell Eng. Co., Kansas City, Mo.

NOT long ago the author moved from a large, well established community that had grown only 14 per cent in the preceding 10 years to a community whose population had increased 100 per cent in the same period. He was used to paying a very nominal water bill. But when the first monthly bill arrived at his new residence, one of the chief problems of the community was brought home with emphasis. The new bill was exactly six times as large as the old one, for approximately the same amount of water.

The problems that confront water works operators in a rapidly expanding community are similar to those in normal communities. The principal difference lies in the degree to which these problems are intensified.

Take a relatively placid community, growing perhaps, because almost every United States city of more than 10,000 population is growing. But the growth is nominal. Then, suddenly, it receives a stimulus. A new industry moves in. A bridge is constructed, tying the community closer to a larger city. New natural resources are discovered or opened up for development, or the government chooses the locality for some ultrasecret, mysterious project.

Assume that the stimulant is a new industry. Of course, the city welcomes it, for it will employ 10,000 persons when in full swing, so it is said. These, plus their families, will swell the population by 30,000–40,000, and business will be good. With the coming of this population increase, all of the available property is rented or sold, and the demand for new homes soars to new heights. The 10,000 employees and their wives spend their checks in the community for groceries, clothing, appliances, and housing. This stimulates the employment of about 3,000 more persons, who are drawn into the community with their families and increase the population by another 10,000–12,000. They, also, buy commodities that again stimulate the employment of another 1,000 persons, who, with their families, increase the population by an additional 3,000. Thus, the employment of 10,000 persons in a basic or primary industry has resulted in a population rise of 50,000–60,000.

Hundreds of communities experienced that type of growth during the war. Of course, the water works had to supply the increased demand. At first more meters were purchased, more services connected, and more street mains laid. Then the pinch was felt at the pumping stations. The trunk mains had to be supplemented, and the treatment facilities and trans-

mission mains enlarged. Finally the supply itself had to be augmented.

Following World War II many industries closed down. Recessions were predicted, but in most communities they failed to materialize. A new era has dawned. It may be too early to call it the "Atomic Age," but not in Tennessee, Nevada, and New Mexico. There the new age was born and is now growing vigorously. Expansion will probably be the major problem of such communities as Los Alamos, N.M., Oak Ridge, Tenn., and Albuquerque, N.M., for several years to come.

The Albuquerque problem is typical. It took the city 80 years to grow from a population of 1,200 to one of 35,000. In the next 10 years, 1940–50, it expanded from 35,000 to 97,000. In 1940 the water department had 9,000 meters in service. In 1950 the number had risen to more than 20,000, and the water department was behind in its meter connections. In 1953 there were 34,400 meters in service. In 1940 the water consumed was 1.4 bil gal, without rationing. Ten years later the figure was 5.4 bil gal, and summer rationing was in force.

It should be noted that, while the population has grown 173 per cent, the consumption of water has increased 281 per cent. This means that the per capita consumption has increased —from 74 gpd in 1930 to 109 in 1940 to 148 in 1950—complicating the problems of the water utility. Even if the city had not grown at all, the demand for water would have doubled since 1930. This vast increase in per capita water demand is due to a combination of the following conditions: [1] a rising standard of living, that is, more homes with modern plumbing, even among the very poor; [2] the great use of water in industry; and [3] in cities like Albuquerque, where the average annual rainfall is only 8.5 in., the increasing use of water for irrigation, particularly necessary for starting new lawns (in the newly built up areas of Albuquerque, the average consumption is 285 gpcd); and [4] air conditioning, the phenomenal growth of which is a subject worth a paper in itself.

Water works facilities are not designed for the average daily requirements, but to meet conditions imposed by maximum-day, peak-hour, and fire demands. The maximum-day demand generally represents the capacity required in the water supply and treatment facilities. At Albuquerque, the ratio of the maximum-day demand to the average daily demand in 1951 ranged from 1.63 : 1 to 2.47 : 1 in the various pressure zones. The average for the city was 2.12 : 1.

The peak-hour demand often includes the lawn-sprinkling load, which occurs from 6 to 7 PM in most cities. Data on hourly demands were not available at Albuquerque, but it was possible to determine the demands for 8-hr periods. The maximum 8-hr demand ranged from 1.14 to 1.95 times the maximum-day demand.

Both the maximum-day and the peak 8-hr demand ratios were greatest in the new residential areas, where, as previously mentioned, the average demand was 285 gpcd. Thus, the maximum 8-hr demands in these areas were as much as 9.5 times the average daily demand per capita for the entire city.

Had the water been available, it is estimated that the peak-hour demand might have been as much as fourteen times the average demand. In new residential areas, consumption during the peak hour is estimated at 2,000 gpcd, which equals a rate of flow of

1.43 gpm per capita. Assuming a family of four at each service connection, each customer was irrigating his lawn, or otherwise using water, at the rate of 5.7 gpm, a figure that approaches the capacity of the average garden hose. This is the greatest per capita demand observed by the author in any city at least 95 per cent metered. Albuquerque is almost 100 per cent metered, and the unaccounted-for water is less than 15 per cent.

It is evident that water works improvements must be designed for future requirements, but therein lies the greatest chance for error in the development of an improvement program. There is no infallible formula for predicting the population of a city 10–30 years hence, and no one can say with certainty what the per capita consumption may become and how the ratios of peaks to average may change. Nevertheless, such predictions must be made, and the construction program must be so arranged that, if substantial changes in the growth pattern take place, it can be adjusted accordingly.

The predictions for Albuquerque were based upon the following assumptions: [1] the population will reach approximately 226,000 by 1970; [2] the average demand will increase to 180 gpcd; and [3] the ratio of peak to average demands will not change materially. It was assumed that the ratio of maximum to average day would range from 2.00:1 to 2.50:1, and the ratio of peak hour to maximum day from 2.00:1 to 3.00:1. The lower value was used for the built-up areas, and the higher for the area of growth. On this basis it was estimated that the demand for the average day would rise from 18.8 mgd in 1952 to 41 mgd in 1970; the maximum day, from 42.4 to 97 mgd; and the peak hour, from 90.1 to 209 mgd. With this information and these assumptions, a master plan for the Albuquerque water system was developed.

The water supply for Albuquerque is obtained from wells in an aquifer of alluvial materials believed to be of glacial and sedimentary origin. The early water supply was obtained from shallow wells, approximately 100 ft deep, and required iron removal and softening. In 1928 it was discovered that a soft, iron-free water could be obtained from wells 450–500 ft deep. All of the newer wells are drilled to that depth. The hardness of the water from the deeper wells ranges from 115 to 130 ppm, whereas that of the shallow well water exceeds 230 ppm.

The ground water supply appears to be adequate for further expansion. It has been recommended, however, that a survey be started, with the establishment of permanent test wells and other controls for developing a continuous record of the ground water table. Many of the existing wells have been overpumped. The consulting engineers have recommended that the pumping capacity of each well should not exceed 700 gpm and that the wells be placed at least 1,500 ft apart.

The treatment required consists of sedimentation, to remove the sand drawn from the wells, and chlorination. By chlorinating ahead of the settling basin, adequate contact time is assured before the water is pumped into the mains. The bacteriological quality of the raw well water is very good. Chlorine provides an extra factor of safety against chance contamination from plant to water faucet.

The distribution system of Albuquerque is divided into seven pressure zones, five to the east of the Rio Grande and two to the west. The water is pumped from the wells to ground level (el 4,950) covered reservoirs for

treatment and storage. It is then repumped successively through each zone to higher reservoirs up to a final elevation of 5,987, more than 1,000 ft above Old Albuquerque. As the city is expanding up the slopes on either side of the Rio Grande, most of the water needed to meet further growth will have to be pumped to the higher elevations.

One of the problems of Albuquerque, and of most other rapidly growing communities, is that of scattered developments, widely separated from the built-up fringe of the city. These areas are usually selected by builders who are seeking low-cost land, freedom from city restrictions and inspections, and latitude for design and development in line with modern ideas on community planning. These motives may coincide with the welfare of the community, but some, to say the least, are costly to it, if it has to pay for the longer trunk mains and higher pumping expenses of the water department, the longer sewer mains, and the longer streets and highways. The other utilities must similarly lengthen power lines, gas mains, and telephone cables to serve these scattered areas, and the rates reflect this extra cost.

The economic importance of this problem to a community is clearly illustrated by the author's personal experience, referred to at the beginning of this paper. The community from which he moved averages 98 service connections per mile of water main, compared to 49 in the one where he now lives. In Albuquerque, the number of services per mile of water main in 1940 was 85. In 1952 it had decreased to 72.

During the past 10 years inflation has been one of the biggest problems of rapidly expanding communities. Construction costs have risen continuously and are now 2.5–3.0 times as high as in 1940. In some years costs have spurted upward as much as 15–20 per cent, while the average increase has exceeded 10 per cent per year. In the rapidly expanding community, this inflationary trend has required substantial rate increases, and in some communities several have been necessary.

The need for keeping up with community growth is a challenge to the water utility. Minor extensions may be handled routinely, but, when the supply runs short or the trunk main capacity proves inadequate, a major program of construction is necessary. Such improvements require time for development. How to induce the public or a city council to become sufficiently concerned about a water shortage that will arise 2–3 years in the future is one of the unsolved problems of the water works industry. It appears that the shortage must be at hand and rationing in force before public support of a major program can be obtained. Albuquerque is typical. It is estimated that the present improvement program is 3 years behind requirements. It may take another 2–3 years to catch up.

From time to time there are alarming reports about the shortage of water. In the words of Malcolm Pirnie, apropos of New York City, "There is no shortage of water, only a shortage of vision." Albuquerque has now caught the vision and has started a 15-year construction program estimated to cost $20,000,000. The program will be financed by general-obligation and revenue bonds. In all probability, water rates will have to be increased, but the master plan of development is now well under way.

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Part A—Material Specifications

Sec. 1A—Scope

These specifications cover fluosilicic acid (H_2SiF_6) for use in the treatment of municipal and industrial water supplies. The specifications are intended for use in connection with Part B (Sampling, Inspection, Packing, and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definition

Fluosilicic acid (H_2SiF_6) is a strong, colorless, acid liquid. The commercial acid contains 20–30 per cent H_2SiF_6. It attacks glass and stoneware and must be stored in rubber- or plastic-lined containers. It has a corrosive action on the skin.

Sec. 3A—Caution

Because of its corrosive action, fluosilicic acid should be handled with care. If it comes in contact with the skin, the part affected should be immediately washed with large volumes of clear, cool water. The material should be stored in the type of container recommended by the manufacturer.

Sec. 4A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 5A—Methods of Testing

The laboratory examination shall be carried out in accordance with Part C (Testing Methods) of this document.

Sec. 6A—Impurities

The fluosilicic acid supplied under these specifications shall contain not more than 0.025 per cent arsenic, 0.005 per cent antimony, 0.01 per cent lead, and 0.025 per cent iodine by weight, nor shall it contain any mineral or organic substances in quantities that would be deleterious for use in water treatment.

Sec. 7A—Rejection

7A.1. Notice of dissatisfaction with a shipment based on these specifications must be in the hands of the consignor within 10 days after receipt of shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within 5 days of receipt of notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the consignor one of the sealed samples taken as described in Sec. 2B.3. In the event that the results obtained by the consignor, on retesting, do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded, unopened, for analysis, to a laboratory agreed upon by both parties. The results obtained by the

referee shall be accepted as final and the cost of the referee analysis shall be paid by the party whose results show the greatest discrepancy from the referee analysis.

7A.2. On the basis of the retest or the referee test, the consignor may remove the material from the premises of the consignee or a price adjustment may be agreed upon by the consignor and consignee.

Sec. 8A—Physical Requirements

8A.1. The fluosilicic acid shall be from "water white" to "straw yellow" in color and shall be free from suspended matter.

Sec. 9A—Acid Strength

The fluosilicic acid shall contain not less than 25 per cent H_2SiF_6 by weight.

NOTE: A less concentrated acid may be specified. To avoid the formation of any precipitate, a soft, clear water (distilled water is preferable, although cation-exchange softened water or water with less than 25 ppm hardness will do) shall be used when diluting the concentrated acid to the desired strength.

Part B—Sampling, Inspection, Packing, and Marking

Sec. 1B—Scope

These procedures for sampling, inspection, packing, weighing, and marking of fluosilicic acid are intended for use with Part A (Material Specifications) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. Samples shall be taken at the point of destination.

2B.2. At least 5 per cent of the containers shall be sampled.

2B.3. Before sampling, the fluosilicic acid in the containers shall be mixed by rolling or other suitable means. A gross sample, with a volume of at least 2.5 qt, shall be collected in a clean plastic or rubber container. Containers lined with acid-resistant plastic, wax, or rubber may also be utilized. After mixing, three 0.5-pint samples shall be provided from the gross sample. They shall be sealed in airtight, moistureproof plastic or rubber containers. Each sample container shall be labeled to identify it and the label shall be signed by the sampler.

When sampling a tank truck or tank car, at least five different 0.5-pint portions shall be taken as a representative sample.

2B.4. Samples shall be held for 30 days before being disposed of.

Sec. 3B—Packing and Shipping

3B.1. Packaging and shipping of all fluosilicic acid solutions shall conform to the current regulations of the Interstate Commerce Commission.

3B.2. Fluosilicic acid may be shipped in steel drums lined with rubber or acid-resistant plastic, in rubber- or plastic-lined cars, or in rubber- or plastic-lined tank trucks. It may also be shipped in smaller containers similarly protected.

3B.3. The net weight or net volume of the containers shall not be less than the recorded weight or volume, or more than 10 per cent greater. If exception is taken to the weight or volume of the material received, it shall be based on the certified weight or volume of not less than 10 per cent of the containers, selected at random from the entire shipment.

Sec. 4B—Marking

Each shipment shall carry with it clear identification of the material and a warning of potential danger in handling. Each unit package shall have marked legibly thereon the net weight or volume of the contents, the name of the manufacturer, the lot number, and the brand name, if any. The container may bear also the statement: "Guaranteed by (name of manufacturer) to meet the specifications of the American Water Works Association for fluosilicic acid."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of fluosilicic acid are intended for use with Part A (Material Specifications) and Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 2C—Sampling

2C.1. Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

2C.2. The laboratory examination of the sample shall be completed within 5 working days after receipt of shipment.

Sec. 3C—Per Cent Fluosilicic Acid

The following alternative methods for determining the percentage of fluosilicic acid may be used:

3C.1—Specific Gravity Method

3C.1.1—*Apparatus:*

(a) Acid-resistant plastic or glass cylinder or dish with sufficient depth to float hydrometer.

(b) Glass hydrometer (long stem) capable of being read to four decimal places. (If the density of the solution varies over a wide range, a set of three or more hydrometers should be available to cover the range.)

3C.1.2—*Procedure:*

Carefully transfer the fluosilicic acid from the sample bottle to the cylinder and adjust the temperature to 17.5°C. Insert the hydrometer and measure the specific gravity. The percentage of fluosilicic acid can be determined from Table 1 (page 1179) or from any standard handbook of chemistry and physics.

NOTE: The hydrometer and other glassware should not be kept in contact with the fluosilicic acid solution any longer than is necessary. After using, the hydrometer and other glassware should be immediately and thoroughly rinsed in clear, cool, running water.

3C.2—Hydrogen Titration Method

3C.2.1—*Principle:*

Titration of ionizable hydrogen in a chilled solution from which the fluosilicate ions have been precipitated as potassium fluosilicate:

$$H_2SiF_6 + 2KNO_3 = K_2SiF_6 + 2HNO_3$$
$$2HNO_3 + 2NaOH = 2NaNO_3 + 2H_2O$$

The titration with ice and potassium nitrate is commonly used in practice, because it closely approximates the method of evaluating the more stable

TABLE 1

*Density of Aqueous Fluosilicic Acid Solutions at 17.5°C**

Specific Gravity	Degrees Baumé	% H_2SiF_6	Specific Gravity	Degrees Baumé	% H_2SiF_6
1.1512	19.0	17.5	1.2335	27.5	26.0
1.1559	19.6	18.0	1.2385	27.9	26.5
1.1606	20.1	18.5	1.2436	28.4	27.0
1.1653	20.6	19.0	1.2486	28.9	27.5
1.1701	21.1	19.5	1.2537	29.3	28.0
1.1748	21.6	20.0	1.2588	29.8	28.5
1.1796	22.1	20.5	1.2639	30.3	29.0
1.1844	22.6	21.0	1.2691	30.7	29.5
1.1892	23.1	21.5	1.2742	31.2	30.0
1.1941	23.6	22.0	1.2794	31.7	30.5
1.1989	24.1	22.5	1.2846	32.1	31.0
1.2038	24.6	23.0	1.2898	32.6	31.5
1.2087	25.0	23.5	1.2951	33.0	32.0
1.2136	25.5	24.0	1.3003	33.5	32.5
1.2186	26.0	24.5	1.3056	34.0	33.0
1.2235	26.5	25.0	1.3109	34.4	33.5
1.2285	27.0	25.5	1.3162	34.8	34.0

* Taken from Lange (ed.), *Handbook of Chemistry*, Handbook Publishers, Inc., Sandusky, Ohio (6th ed., 1946), p. 1280.

acids, and suffices for the usual trade purposes.

3C.2.2—*Reagents:*

(a) Ice.

(b) Potassium nitrate, saturated solution.

(c) Sodium hydroxide solution, standard, approximately 0.5*N*.

(d) Bromthymol blue, 0.2 per cent solution.

3C.2.3—*Procedure:*

Pipet 25 ml of sample into a 500-ml volumetric flask. Dilute with distilled water to the mark and mix. Put a handful of clean ice into a 400-ml beaker, add 25 ml potassium nitrate solution, and pipet a 25-ml aliquot of the sample solution into the beaker. Wash down the sides of the beaker and, stirring constantly, promptly titrate with standard sodium hydroxide, using bromthymol blue as indicator. The endpoint has been reached when the blue color persists for at least 30 sec. On longer standing, the indicator will turn yellow.

3C.2.4—*Calculation:*

$$\text{Vol. of sample} = 25 \times \frac{25}{500} = 1.25 \text{ ml}$$

$$\text{Weight (g) of sample} = 1.25 \times \text{sp gr (at room temp.)}$$

$$\frac{\text{ml NaOH} \times \text{normality} \times 0.072 \times 100}{\text{weight (g) of sample}} = \%\ H_2SiF_6$$

3C.3—Determination of Free Acid

3C.3.1. It is obvious that the preceding method will include any free acid other than fluosilicic acid that may be present. If it is desired to distinguish between fluosilicic and other acids, place the beaker, whose contents have been titrated as above, on a hot plate and bring to a boil. Titrate the hot solution with the standard sodium hydroxide to the neutral point of the bromthymol blue. This titration breaks down the fluosilicate radical of the potassium fluosilicate:

$$K_2SiF_6 + 4NaOH = 2KF + 4NaF + SiO_2 + 2H_2O$$

If the fluosilicic acid is 100 per cent pure, the milliliters of NaOH used in the cold titration will equal exactly half the milliliters of NaOH used in the hot titration. If free acid other than fluosilicic is present, the cold titer will exceed half the hot titer. If fluosilicate salts are present, half the hot titer will exceed the cold titer.

3C.3.2—*Calculation:*

$$\frac{\left[\text{ml NaOH (cold titer)} - \dfrac{\text{ml NaOH}}{2}\text{ (hot titer)}\right] \times \text{normality} \times 0.02 \times 100}{\text{weight (g) of sample}}$$

$$= \text{per cent free acid other than fluosilicic expressed as HF}$$

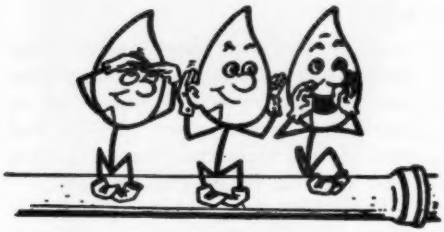
$$\frac{\dfrac{\text{ml NaOH}}{2}\text{ (hot titer)} \times \text{normality} \times 0.072 \times 100}{\text{weight (g) of sample}} = \%\ H_2SiF_6$$

Comments on Specifications Invited

A total of five tentative specifications were published in the Journal during 1954 (including the November issue; none will be published in December). AWWA members are requested to file without delay any serious criticisms or suggestions they may have with regard to any of these documents. Comments should be addressed to: Secretary, American Water Works Assn., 521 Fifth Avenue, New York 17, N.Y.

A list of the specifications follows:

Specification	Issue of Journal
Sodium Pyrosulfite—B601	Jan. 1954
Sodium Silicofluoride—B702	Aug. 1954
Rubber-seated Butterfly Valves—C504	Sep. 1954
Cement-Mortar Lining of Water Pipelines in Place—Sizes 16 Inches and Over—C602	Oct. 1954
Fluosilicic Acid—B703	Nov. 1954



Percolation and Runoff

Not where you find it any more, water, these days, seems to be when you find it. At Ridgewood, N.J., for instance, last summer's shortage was so severe that the water department decided to enter a "Don't Waste" float in the July 4 parade, and proceeded to drip away with first prize. But by September 16, a couple of hurricanes later, the city commissioners were being swamped with complaints of too much water—in creeks, in rivers, in the ground, but mostly in basements all through the area. At Portland, Ore., similarly, a series of dry summers indicated the wisdom of a new pipeline. But no sooner was the additional capacity available than two especially wet years not only made it unnecessary, but have been undoing the water board financially as well, with a drop in water revenue that totaled more than 35 per cent during the last fiscal year. Or in Brooklyn, N.Y., indeed, where the ground water supply, as much as 35 ft below sea level in 1941, is now flooding basements and boiler rooms all over town.

The Brooklyn upwelling, contrary to a rumor started by some Giant fan, has not been due entirely to the tears of Dodger rooters, but in good part is the result of discontinuing use of ground water for public supply in 1947, when the Brooklyn system was tied in with the rest of the New York City network, distributing an upland supply. The Portland drowning of demand is, of course, only a temporary difficulty—unfortunate financially in juxtaposing maximum supply with minimum demand, but certainly happier than the other way around. But the Ridgewood dilemma is typical of those faced by thousands of other communities, where too much follows too little season after season, year after year. Actually, the problem is merely one of putting some of the excess aside for an unrainy day. Only trouble is there are no savings banks available and safe deposit vaults are either unavailable or so expensive that the public cannot or will not pay for them.

Too bad it's not with water that we're asked to say "When!"

'Raus mit Strauss—Rear Admiral Lewis L., that is, chairman of the Atomic Energy Commission. And what arouses us is the Admiral's statement on the September 19 radio and TV edition of *Meet the Press* that "water today . . . is too cheap to be metered." Were he one of those old sea dog admirals, we might be able to understand both the attitude toward water and the penchant for strong

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talk, but from the beach-bound brass of the AEC it's almost inexcusable. It was to square him away, then, that Secretary Jordan took time out to provide the Admiral some of the facts of water works life in a letter later printed in the New York *Times*. Meanwhile, Col. H. S. Bennion, managing director of Edison Electric Institute, took just as forceful and public issue with the Admiral's intimation that electric power generated by atomic energy would also be cheap enough not to require metering. From AWWA, an accounting of the expenses of water supply; from EEI, knowledge that only about 10 per cent of the cost of electric power is attributable to its generation; from the Admiral, silence!

Not for long, though, for in less than a week fur was flying in the field of nutrition, following the Admiral's suggestion that spinach might not be good for growing children. There the situation was just a little different, in that there appeared to be some radioisotopic evidence to back up his conclusion. But with some experts in the field rising to dispute the suggestion and all agreeing to the unwisdom of starting a spinach scare, the Admiral made few friends among nutritionists, food packers, or, indeed, mothers.

What with these and the almost daily statements he must make on the potentialities of atomic energy in every field of endeavor, we can sympathize just a bit with the Admiral, understanding how little time he must have to consider the possible implications of his statements and how great the temptation to furnish the kind of sensationalism expected of atomic energists. On the other hand, knowing how strict AEC can be about loose talk in one direction, we'd almost expect them to watch their words in other respects as well, particularly words that take so much unsaying.

Phooey on Lewie!

Harold E. Babbitt has retired as professor of sanitary engineering at the Univ. of Illinois, ending a 41-year career that has helped to produce 2,800 engineers, a handful of books (one of which has seen seven editions), countless technical articles and abstracts, and a better understanding of water supply and waste disposal problems everywhere. He has moved to Seattle, where he plans to continue work on his technical books and perhaps practice as a consultant as well.

Howard J. Evans, chief engineer of the Pittsburgh Equitable Meter Div., and H. A. Altorfer, chief engineer of the Nordstrom Valve Div., have been appointed chief engineer and manager of two Rockwell Mfg. Co. research and development departments—Evans to work on gas products, and Altorfer on valves.

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Prayday in Iowa was October 15, when the Iowa Section dedicated the banquet of its Cedar Rapids' meeting to celebrating the "50 years of service and contributions to the water works industry" of John Pray, manager of the Fort Dodge municipal utilities, the section's present representative on AWWA's Board of Directors, and an AWWA member for more than 40 years. AWWA brass present to help some 200 Iowans do the celebrating were Past-President Jack Hinman of Iowa City, who made the presentation of a handsome 10x12-in. bronze plaque; President Dale Maffitt of Des Moines; and Vice-President Frank Amsbary, on hand to present out-of-state felicitations. Prayday was *really* Prayday, too, for October 15 is John's birthday as well.

James S. Peters has retired as general manager and chief engineer of the Marin Municipal Water Dist., San Rafael, Calif., with which he has been associated for 40 years. His services will still be available to the district on a consulting basis, however. William R. Seeger, formerly assistant to Peters, succeeds him. In addition, B. J. Brusatori, secretary-treasurer, and L. J. Stefani, superintendent, have been appointed assistant managers.

Robert A. Cyphers has been appointed Atlanta district manager of turbine sales for the S. Morgan Smith Co. Formerly with company headquarters at York, Pa., he will be stationed at 3240 Peachtree Rd., N.E., Atlanta 5, Ga.

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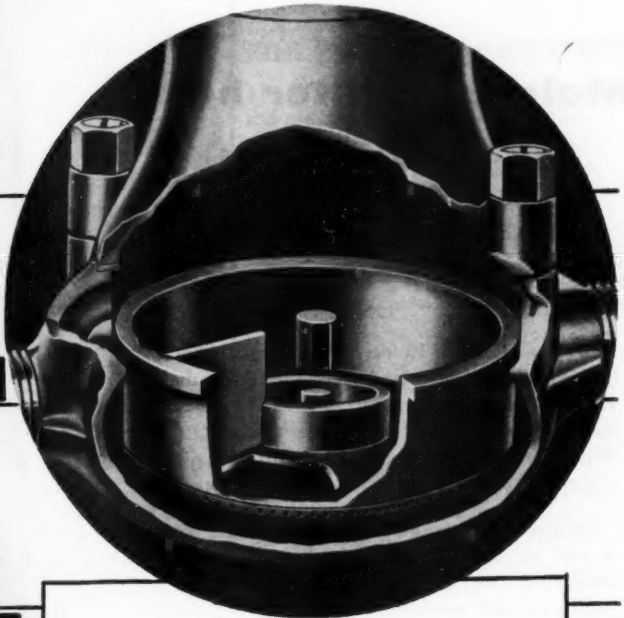
CALMET



The slow moving oscillating piston makes only 256 oscillations per cubic foot of water in the ⅝ inch size meter; retains its low flow accuracy longer with less upkeep.

"THE METER YOU CAN COUNT ON"

Manufactured by

Well Machinery & Supply Co., Inc.

Fort Worth, Texas

See ISOPOR Ad on Page 65.

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Robert C. Dennett (above), engineering consultant of the National Board of Fire Underwriters, has retired after 50 years of continuous service. In the course of his career, he has surveyed the water supplies of 150 major cities, advised the government on fire protection during two wars, traveled extensively, and contributed much to the safeguarding of the country's growth against destructive fire and conflagration.

It's Fluoridelphia now, the nation's third largest city having initiated the world's largest fluoridation program when Mayor Joseph Clark and Water Commissioner Samuel S. Baxter on September 22 opened the valve that started fluoridated water flowing to the first of the more than two million persons now being served there. And if the aura wasn't all one of brotherly love, at least the program was permitted to get under way on schedule, petition for a temporary injunction having been denied, leaving a suit against the program to be fought out later.

What with Chicago scheduled to join the fluoriders as of the beginning of the year, Philadelphia's firstness is destined for a quick dwindle to secondity. Thirdition, however, isn't quite in sight, for New York's City Council has yet to give the idea the benefit of its serious attention, stalled and appalled, apparently, by the fact such a large proportion of the fluorides added "wouldn't be doing anyone any good." For a city extravagant enough to tolerate flat-rating in the face of one shortage after another, that sounds a little out of character. Fortunately, no one yet has suggested economizing on chlorination by treating only that part of the supply used for drinking, cooking, and, perhaps, washing.

At any rate, Philadelphia's two million have boosted the total population served artificially fluoridated water to above the twenty million mark, despite the loss of 81,682 served by the Greensboro, N.C., where fluoridation was discontinued pending a November referendum. Net total of participating communities as of October 1 was 1,012.

A subdivision without a single main extension problem has at last been invented. It was at Little Rock, Ark., that a new real estate corporation was formed last month "to subdivide and convey title of such area or areas of said planet Mars to competent persons for suitable remuneration." And the three founders of the Planet Mars Development Corp. are already publicizing Mars' mellow mean temperature of 48°F. and its 687-day year that will cut your age almost in two. Not likely to be mentioned except to the water works field is the fact that there is no water on Mars and, thus, nothing to extend from. No wonder Mars Bars are so often advertised on radio and television.

Robert S. Hinkle has been appointed to the sales force of Reilly Tar & Chem. Corp., Indianapolis. His headquarters will be at Granite City, Ill., where he will assist E. E. Goodman, district manager.

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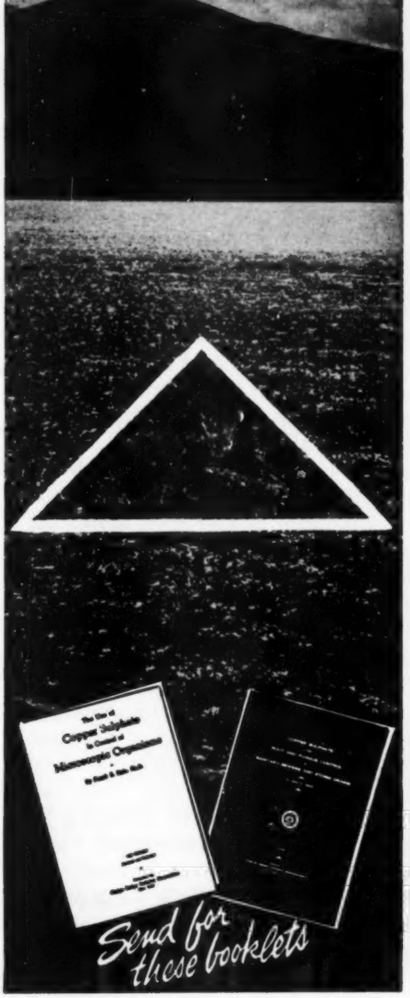

Send for these booklets

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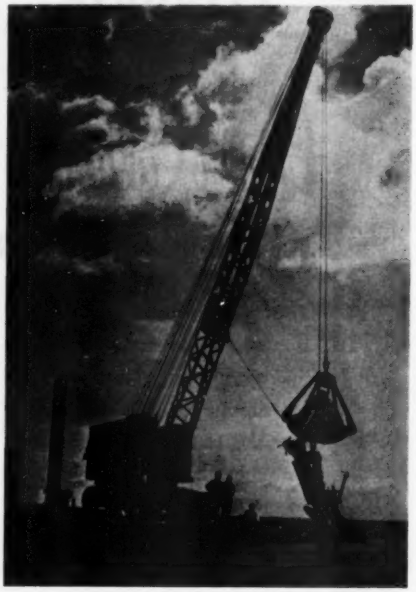
Water Workers in "Under" Wear



Well Washed Model T

In his element in no uncertain terms was Supt. Bob Hansen of the Mount Clemens, Mich., water purification plant and pumping station last month —not just in it, either, but a good bit over his head, at and even under the bottom of Lake St. Clair, the system's source of supply. Object of this deep interest was an emergency inlet shown on the blueprints of the intake structure, but forgotten if not gone in the 25 years since the line was installed. Emergency that brought it to mind just then was an expansion program for which no more than $800,000 could be raised—$800,000 that was all needed for the planned doubling of plant capacity. Immergency that brought it to hand from beneath several feet of muck was the Aqua-Lung diving of Bob and a number of his crew to probe for the valve that could save them the $300,000 price of a new intake.

Found, opened, tested, and proved adequate to provide the necessary additional intake capacity, and thus to save the full $800,000 for plant expansion, was the auxiliary inlet. Not, however, until after the exaquation of a Model T Ford with 1930 license plates (see cut) and three cases of Prohibition booze (see revenue agents). As for the Aqua-Lunging, Bob was so taken with the equipment he purchased to save the high cost of professional divers that he hired a barge and went out for a look at his regular intake crib and there reported finding the intake pipe cut off from the crib, requiring considerable additional underwater activity. Remembering the rum-running notoriety of Lake St. Clair in days past, some of the non-

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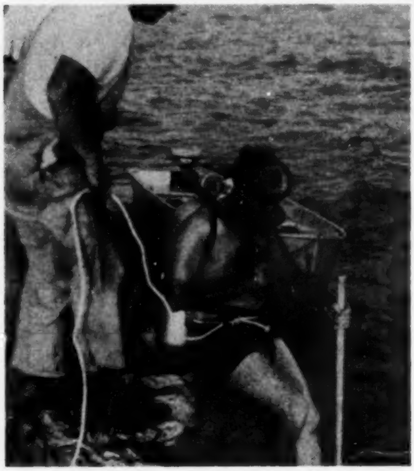
waterworking Mount Clemensians are beginning to see strong reason for a dive or two themselves, though Bob's fondness for his own element certainly places him above suspicion on that count. Besides, the corks would be a floating giveaway.

Coming up for air, though, we can see the whole operation as worth even more than the $300,000 saved, in public relations good—what with front page picture stories, human interest,



Hansen Is as Hansen Does

the suspense of a search for buried riches, and inescapable evidence that the water department goes all out, if not-all under, to give a maximum of service at a minimum of expense. With the kind of public relations job that has been done in Mount Clemens over the past few years, the proof of efficiency could come as no great surprise, but, then, there's no substitute for substantiation.

Elementary, our dear Hansen!

Not just big, but BIG, business is what water supply must have become to rate acknowledgment by as knowing an authority as *The Exchange,* publication of the New York Stock Exchange. Not mere mention, either, among the business bilge, security scoops, or dividend dirt, but the feature story of the September issue—entitled "Water Is Big Business" and authored by A. R. Fisher, president of Johns-Manville Corp. All of which, together with a reasonable rate of profit, might make us a good investment.

A little less than big perhaps, in that the president of the Denver Water Board rates a salary of only $50 a month. But really bigger than ever in the light of his refusal to resign that $50 position to give his own construction firm a $1,405,000 contract. "He" is Nicholas R. Petry, whose firm, N. G. Petry Construction Co., made the low bid on the construction of a six-story public library. Anyone less than a BIG businessman would have resigned his water board post to comply with the city charter provision forbidding "city officials" from holding contracts with the city—especially when the city attorney was helpful enough to point out that his contract "would be the most advantageous to the city." But Petry held on to the position and let the job go.

Which ought to make water too big for its britches!

The Portland Cement Assn. has moved its Eastern Regional and New York District offices to 250 Park Ave., New York 17. M. J. McMillan continues as district manager and W. J. McIntosh as district engineer.

The Cast Iron Pressure Pipe Inst. and Sidney E. Linderman, its executive vice-chairman, have moved to new offices in the Pennsylvania Bldg., 425—13th St., N.W., Washington 4, D.C.

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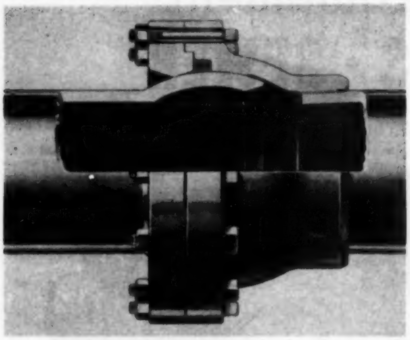

River-crossing pipe that permits a deflection of 15 deg between 18-ft lengths has just been introduced by James B. Clow & Sons. This deflection is obtained without impeding the waterway because of the ball-and-socket design of the cast-iron pipe ends (above). Besides nuts and bolts, there are only three parts to each joint: the pipe, follower ring, and rubber gasket. A folder offering complete details is available from the company at 201–299 N. Talman Ave., Chicago 80, Ill.

W. H. Wisely—better known as Pete—will succeed W. N. Carey, retiring executive secretary of the American Society of Civil Engineers. Wisely, who has been executive secretary and editor of the Federation of Sewage & Industrial Wastes Assns. for the past 14 years, will join the ASCE staff on January 1, and will be known as associate secretary until Col. Carey's retirement becomes effective May 1. His post with FSIWA will be filled by Ralph E. Fuhrman, deputy director of sanitary engineering for the Dist. of Columbia.

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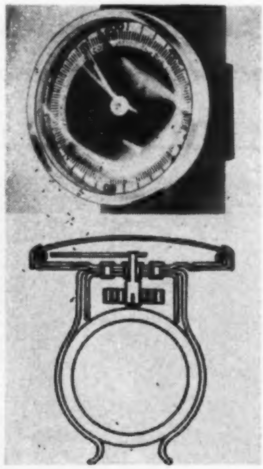
Mixing his drinks these days is one of our less desirable acquaintances—a pest called *Desulfovibrio desulfuricans.* Long known for so unslakable a thirst for water that he dug holes in pipe to get at it, *Deedee* has now apparently turned his attention to oil as well, and in the vicinity of Ventura, Calif., has been chewing his way through steel oil well casings all over the place. Inasmuch as his mooching off oil wells takes place at depths from 5,000 to 12,000 ft, the price per drink has been up around $100,000, making the industry a little less than anxious to continue setting them up. Use of highly alkaline muds around the casings seemed to dampen *Deedee*'s spirit for a while, but he soon got used to it. Now they're going after him with arsenic and hope in a couple of years to be able to tell whether that will permanently spoil his taste for oil or merely adjust it. Meanwhile, though oil and water don't mix, no one in the water works field has reported any great relief from *Deedee*'s thirst—and there isn't much help to be looked for in an arsenic control technique.

B-I-F Pacific, Inc., is the new name of Builders-Pacific, Inc., the West Coast affiliate of B-I-F Industries, Inc., of Providence, R.I. The organization, with offices at San Francisco, Los Angeles, and Phoenix, will continue to offer sales and service representation for Builders-Providence, Omega Machine Co., and Proportioneers, Inc.

A heavy duty pipe cutter that features an extra strong frame and quick-release pins for change of cutter wheels has been added to its Pipemaster line by Erie Tool Works, Erie, Pa.



A surface thermometer for use on pipes (above) has been developed by Pacific Transducer Corp., 11921 W. Pico Blvd., Los Angeles 64, Calif. The thermometer is made to attach to pipes ½ to 2 in. in size by means of a simple spring clip, and is available in two ranges: −50° to 250° and 70° to 370°F. A stable reading is obtained within 5 min, and accuracy of ±2°F is claimed. Cost of the instrument is $6.75.

Morris M. Cohn has been appointed adjunct professor of civil engineering at the College of the City of New York (CCNY). He continues as editor of *Wastes Engineering* and associate editor of *Water Works Engineering* for the Case-Shepperd-Mann Publishing Corp.

Emile P. Leclerq, formerly associated with Gibbs & Hill, Inc., has joined the New York consulting firm of Seelye Stevenson Value & Knecht as a specialist in water treatment and municipal and industrial waste disposal.

(Continued on page 50 P&R)


HIGH
OR
LOW
TENNESSEE CORPORATION
ferri-floc
FERRIC SULPHATE

(*Continued from page 48 P&R*)

Pressure politics were played with water system psi at China Springs, Tex., this year, when the school board proposed a tax increase to provide the funds for a new school building. It was Mrs. Vergie Humberson, owner of the town's water supply, who led the protest—and most effectively, too, simply by shutting off the water. No question, then, that thirst came first, but whether it was for water, for knowledge, or for revenge has not yet been reported. All of which may suggest that silent lack of service *is* enough. Sort of like suicide, that is!

Speaking of education always reminds us of our multilingual poet friend, Wendell LaDue, Akron's water superintendent and poet laureate. It is without his permission that we reprint below a few telling lines from his most recent epic, "Kinendux Ariden":

Seville Dair Dago
  Tousen Bussis Inuro
Nojo Demstrux
  Sumit Cousin
Sumit Dux.

No, it wasn't for his prowess at the four-bagger that they called him Homer LaDue back at U.S.C. He was odd y' see.

Three new district sales offices have been opened by Chain Belt Co. of Milwaukee: at 501 E. Morehead St., Charlotte, N.C.; at 1720 Section Rd., Cincinnati, Ohio; and at Moline, Ill.

(*Continued on page 92 P&R*)

The Reading Meter

Water Supply and Waste-Water Disposal. *Gordon Maskew Fair & John Charles Geyer. John Wiley & Sons, New York (1954) 973 pp.; $15*

This new text on "new and used water" represents a substantial achievement. It is comprehensive, excellently illustrated, and includes working examples to pin down the principles discussed. As there are very few topics of interest to the sanitary engineer which are not discussed, it is inevitable that, despite the great length of the book, the treatment of specific subjects must be concise almost to the point of oversimplification. On the other hand, the emphasis upon underlying principles to the comparative neglect of practice should mean less obsolescence as the years go by. Specific items of equipment, for example, are almost entirely ignored, but the methods of appraising them are given, and these methods are relatively stable. The water half of the book includes discussions of physical properties, hydrology, rainfall, storage, ground water, distribution, biology and chemistry, and treatment methods. In addition, general chapters on statistics, consumption, and water sanitation are included.

Manual of British Water Supply Practice. *Institution of Water Engineers, Parliament Mansions, Abbey Orchard St., London S.W.1, England (2nd ed., 1954) 963 pp.; $8*

The second edition of this valuable work appears only four years after the first—sufficient evidence of its popularity and usefulness. With some modifications, the structure of the earlier work has been retained, but each chapter has been revised—even to the bibliography—and a new chapter on the economics of water engineering has been added. This addition constitutes a fruitful approach to a highly rewarding aspect of water supply engineering. Unfortunately it is marred by poor choice of one very minor example in raising the question whether fluoridation, for example, might not be more "economically" applied individually. This approach misses the entire point of the true economics of public water supply fluoridation, which offers, at an irreducible minimum of cost, freedom from error, precise control, and above all universality—but the point is not pressed, and its utterance is undoubtedly attributable to lack of familiarity with this particular topic outside the US and Canada. On the whole, the book is a storehouse of helpful reference material, and its particular applicability to British practice should not prevent it from being useful also on this side of the ocean.

The Conservation Yearbook—1954. *Erle Kauffman, ed. The Conservation Yearbook, 1740 K St., N.W., Washington 6, D.C. (1954) 320 pp.; paperbound; $6*

In its third annual edition *The Conservation Yearbook* continues to serve as a directory of agencies and organizations concerned with the conservation of our renewable natural resources and a source of much reference material on national and state parks and forests, wildlife refuges, and wilderness areas. The directory of soil conservation districts and state and national officials concerned with such matters should be especially helpful.

(Continued on page 54 P&R)

The Reading Meter

(Continued from page 52 P&R)

Water Supply Watershed Protection: *A report of the Task Force on Watershed Protection. Subcommittee on Water Pollution Control, Columbia Basin Inter-Agency Committee (1954) 17 pp.; paperbound; free from R. R. Harris, Public Health Service, 211 US Courthouse, Portland 5, Ore.*

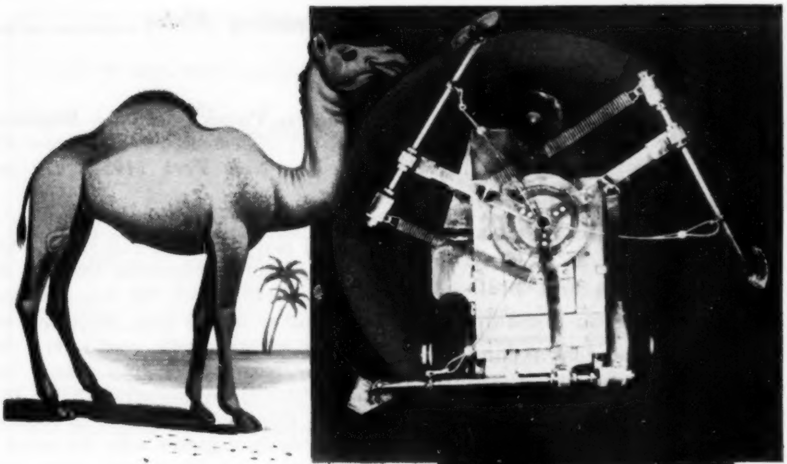
"Watershed protection is not a separate job; it is part of every job on a watershed, and must be so considered." In addition to stressing the great need for protective work, the task force points to the rehabilitation of many watersheds, and the study of conditions on all, as being vitally important.

Water Conditioning for Industry. *Sheppard T. Powell. McGraw-Hill Book Co., N.Y. (1954) 548 pp.; $9*

The special forms of water treatment which are most needed for industrial processes are fully treated in this excellent book, together with such water-connected problems as boiler maintenance and cleaning, cooling tower design, and corrosion control. Because the conditioning of boiler feedwater is much the same as its preparation for many industrial applications demanding high purity, this subject is discussed in great detail; and because Mr. Powell is an authority in this field the result is an assembly of information not readily to be met with elsewhere.

In addition to these "advanced" chapters, the book discusses such elementary and yet complex matters as settling, coagulation, filtration, cold- and hot-process softening, and ion-exchange softening and demineralization. A chapter on analytical procedures and an appendix of useful tables and charts completes the presentation.

(Continued on page 56 P&R)



The Reading Meter

(Continued from page 54 P&R)

Modern Physics for the Engineer. *Louis N. Ridenour, ed. McGraw-Hill Book Co., New York (1954) 499 pp.; $7.50*

The engineer for whom this book is intended may need to recall rather more of his scientific education than he remembers having had, but this objection, depending as it does upon subjective and personal considerations, would vary considerably from reader to reader. Certainly there is no quarrel with the purpose of this book, which is to acquaint the practicing engineer with the areas of exploration and discovery, with new-found facts and relationships, and with modern concepts of the world about us. Anything that will broaden the basis of understanding of our technical specialists is a good thing, and if this book can help even a few engineers to a better understanding not only of other areas of technology but also of their own fields, it will richly have served its purpose.

From the chapter on "High-pressure Phenomena With Applications to Geophysics" by David T. Griggs, UCLA professor of geophysics, we have extracted a few statements which will interest all makers and users of valves and fittings—in other words, everybody. Prof. Griggs had been explaining how the principle of the unsupported area is applied (as in a rubber bathtub stopper, for example) to make leakproof packings for high-pressure apparatus. He goes on to say: "This packing just seals tighter and tighter as pressure is increased. . . . Conscientious application of this principle to household plumbing fixtures would improve the pleasure of married life. One of the aggravations of high-pressure workers is constant leakage in the low-pressure end of the hydraulic systems, where commercial fittings are used for convenience." In this respect, practically all of us turn into "high-pressure" workers sometimes!

Professional Services

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

BACTERIOLOGY

The Bacteriological Analysis of Water. R. Buttiaux & T. Leurs. Ann. Inst. Pasteur de Lille (Fr.), **5**:87 ('52–'53). Two topics are dealt with by authors—influence of temperature of incubation on citrate utilization by coliform organisms isolated from water and inhibitory effect of lactose desoxycholate citrate agar on *Salmonella* organisms which have had more or less prolonged immersion in water. By incubating in Simmons's citrate medium at 30°C for 20 days, strains of *Esch. coli* Type II and and Irregular Type I were observed to grow on medium, but strains of Irregular Type II and *Esch. coli* Type I did not. Authors conclude that this is evidence that Irregular Type II is closely related to *Esch. coli* Type I, and Irregular Type I and *Esch. coli* Type II are more closely related to Intermediates. In addition, citrate-utilizing coliform organisms were observed to grow more rapidly on medium at 30°C than at 37°C and authors recommend lower temperature for this test. It was demonstrated that *S. typhi, S. paratyphi B* and *S. enteritidis* strains did not grow so well on desoxycholate agar after being some time in water and, in fact, after 6–12-hr exposure, some strains did not develop at all. It is therefore recommended that water sample should be enriched first in liquid medium such as selenite or tetrathionate broth before being plated out on solid differentiating media.—*BH*

Coliform Detection in Water by a Single-Step Technique Using the Membrane Filter. A. A. Hajna & S. R. Damon. Pub. Health Rpts., **69**:58 ('54). Single-step procedure for coliform detection in water analysis using membrane filter described. Formula for desoxycholate lactose broth to be used in MF technique is given. Advantage of desoxycholate lactose broth medium in MF procedure for water analysis lies in fact that enrichment of filter is eliminated. With this technique, results are obtained earlier than by standard methods of water analysis. Many false-positive lactose broth tests encountered in standard methods of water analysis are eliminated.—*PHEA*

The Effect of Storage on the Coliform and *Bacterium coli* Counts of Water Samples. Storage for Six Hours at Room and Refrigerator Temperatures. Committee Report. J. Hyg. (Br.), **51**:559 ('53). This investigation was concerned with changes that occurred in coliform and fecal coli content of water samples on storage at room and refrigerator temperatures for 6 hr as compared with those occurring after 24-hr storage. Examination was conducted by 70-tube method using twofold diminishing volumes. Percentages of samples showing significant change corresponding to at least doubling or halving of coliform content on storage were: [1] at room temperature after 6 hr, 24.7%, and after 24 hr, 38.3%; [2] at refrigerator temperature after 6 hr, 25.0%, and after 24 hr, 33.9%. Percentages of samples showing significant change in fecal coli content on storage were: [1] at room temperature after 6 hr, 18.7%, and after 24 hr, 34.6%; [2] at refrigerator temperature after 6 hr, 10.4%, and after 24 hr, 25.0%. Changes were preponderantly decreases, and most of large changes occurred after 24 hr. Investigation has shown that fewer changes occur after 6-hr storage than after 24-hr storage, and that storage for 6 hr at refrigerator temperature is preferable to storage for 6 hr at room temperature. Even so, some samples show significant changes after 6-hr storage at refrigerator temperature; coliform content is significantly altered in 25% of samples and fecal coli content in 10% of samples. Samples of water should, therefore, be examined as soon as possible after collection—certainly within 6 hr—and during period of transport to laboratory they should be kept cold, by ice, if possible.—*PHEA*

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See ISOPOR Ads on Pages 38 and 39.

(Continued from page 64)

The Production of an Alkaline Reaction in Bacto S.S. Agar by Coliform Bacilli. J. J. LAWRENCE. Path. Bact., **65**:258 ('53). Small number of strains of Gram-negative bacilli, isolated from water and from patients suffering from gastroenteritis, appeared to be lactose-fermenting organisms when colonies first developed on Bacto S.S. (*Salmonella-Shigella*) agar, but within 24–48 hr some typically red colonies became opaque white, surrounding medium became alkaline, and colonies were indistinguishable from those of nonlactose-fermenting organisms. On MacConkey's agar, strains showed no tendency to revert to alkaline side. It appeared that alkaline reversion on S.S. agar resulted from production of alkali from beef extract and citrate, 2 constituents which are absent in MacConkey's agar. Possibility of confusion between true nonlactose fermenters and these strains may be overcome by adding an extra 1% of lactose to Bacto S.S. agar before pouring plates.—*WPA*

Water Examinations by Membrane Filter and Most Probable Number Procedures—Committee Report. P. KABLER. Am. J. Pub. Health, **44**:379 ('54). Results of 1,706 water samples examined simultaneously by membrane filter and *Standard Methods* MPN procedures are reported. This study was carried out during year Jul. 1, '52–Jun. 30, '53 under joint auspices of APHA, AWWA, and R. A. Taft San. Eng. Center, USPHS. Sanitation laboratory services of 8 states and one city board of health participated in work. Results of two methods are compared on basis of 95% confidence limits of confirmed MPN. On this basis, results of 1,260 (73.8%) of 1,706 are in agreement. Of 650 samples having coliform content in range associated with potable waters, 571 (88%) show results in agreement. Results indicate that test procedures do not measure precisely same group of organisms and that sanitary significance of differences in results of procedures is yet to be determined.—*PHEA*

Comparison of the MF and MPN Techniques in Examining Sea Water. M. W. PRESNELL, W. ARCISZ & C. B. KELLY. Pub. Health Rpts., **69**:300 ('54). Coliform densities were obtained by simultaneous examination of sea water samples by MF and MPN methods. Comparison of data revealed that techniques gave results 87.1% in agreement. Results obtained from waters having large coliform counts have greater percentage agreement than results obtained from water having low coliform count. Water turbidity can greatly influence coliform recovery rate and should be considered in conjunction with bacterial density in determining volume of sample to be filtered. Use of small replicate volumes of water is indicated where single large volume from sources having low bacterial numbers produces overgrowth. On basis of results from present study, it is concluded that membrane filter method is reliable technique for determining coliform densities of sea water if due regard is given water turbidities and bacterial densities in determining volume of sample for filtration. —*PHEA*

Determination of Bacterial Count With the Help of Turbidity Comparison Tubes and the Stage Photometer and Nephelometer of Zeiss. E. Z. MEYER. Z. Hyg. Infektionskrankh. (Ger.), **137**:367 ('53). Author describes use of simple tube for bacterial counts by comparison of turbidity. Method of calculating and compensating for error by nephelometric measurements is described. Nephelometer measurements can be used for *Salmonella* counts in numbers between 1.1×10^{9}/ml and 10^{8}/ml. Stage photometer is unsuitable.—*WPA*

The Use of Metabolites in the Restoration of the Viability of Heat and Chemically Inactivated *Escherichia coli*. F. HEINMETS, W. W. TAYLOR & J. J. LEHMAN. J. Bact., **67**:5 ('54). Experiments indicate that suspensions of *Esch. coli*, strain B/r, which have been sterilized by action of heat, chlorine, benzalkonium chloride, and ethyl alcohol contain viable cells when incubated with various metabolites of tricarboxylic acid cycle. When such "sterile" suspensions are incubated in buffer or in nutrient broth, no viable cells can be demonstrated. In present series, following metabolites were most effective in producing reactivation: [1] Heat "killed": sodium citrate, lactic acid, and oxalacetic acid; [2] chlorine "killed": sodium citrate, malic acid, and oxalacetic acid; [3] hydrogen peroxide "killed": sodium citrate, lactic acid, and *cis*-aconitic acid; [4] benzalkonium chloride "killed": sodium citrate, lactic acid, *cis*-aconitic acid, and isocitric

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acid; [5] ethyl alcohol "killed": *cis*-aconitic acid, α-ketoglutaric acid, succinic acid, etc.; [6] combination of 11 metabolites produced highest reactivation. Reactivation processes of bacterial cells are discussed in terms of resynthesis of enzymes and reestablishment of cyclic processes. It is indicated that conventional testing and culturing methods are not adequate to determine levels of "complete" sterility.—*PHEA*

The Effect of Sodium Thiosulfate on the Coliform and *Bacterium coli* Counts of Nonchlorinated Water Samples. COMMITTEE REPORT. J. Hyg. (Br.), **51**:572 ('53). It has been practice since 1939, as advocated by Ministry of Health, to place sodium thiosulfate in bottles used for sampling chlorinated water. In order to avoid duplication of types of bottles, some laboratories add thiosulfate to all bacteriological sampling bottles. Amount required has never been specified and question was raised as to whether or not presence of thiosulfate had any noticeable effect upon coliform counts in samples of nonchlorinated water during transit from point of collection to laboratory. 0.1 ml of 3% solution of crystalline sodium thiosulfate in 6-oz. bottle is sufficient to neutralize up to 5 ppm of residual chlorine; use of large quantities of thiosulfate is unnecessary, except possibly for some swimming pool samples. Investigation has shown that this amount of thiosulfate has no significant effect on coliform content of nonchlorinated water samples during 6-hr storage at refrigerator temperature. It appears, therefore, that there is no disadvantage in adding this amount to all water sampling bottles.—*BH*

Enumeration of *Streptococcus faecalis*, With Particular Reference to Polluted Waters. L. A. ALLEN, M. A. F. PIERCE & H. M. SMITH. J. Hyg. (Br.), **51**:458 ('53). Glucose–yeast extract–sodium azide agar medium satisfactory for growth and enumeration of *Str. faecalis* is described. Inhibitory actions of high temperature (45°C) and azide on attenuated organisms were largely

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overcome by preliminary period of incubation (resuscitation) in double-strength glucose broth before addition of azide-agar portion. Bromcresol purple indicator was added because neutral red was inhibitory for some strains of *Str. faecalis.* Phosphate, as potassium salt at concentration of 0.7%, if autoclaved with remaining constituents of medium, exerted depressing effect on count. Added separately it showed no inhibitory action.—*PHEA*

The Detection of Typhoid Bacteria in Water. H. Thiele & E. Brinkmann. Z. Hyg. Infektionskrankh. (Ger.), **137**:374 ('53). Authors describe investigation to determine most suitable method of detecting typhoid bacteria in water and to develop reliable procedure which would also be suitable for bacteriological examination of sewage and polluted surface waters. As Wilson and Blair's bismuth sulfite medium is specially suitable as selective medium, experiments were made with 5 forms of it. Best results were obtained with Lovrecovich's modification, containing more ferrous sulfate, ¼ as much sodium sulfite, and 10 g of bismuth ammoniocitrate instead of 6 g as in original medium. This medium strongly checked accompanying bacteria and permitted easy recognition of typhoid and paratyphoid bacteria. Modified medium of Czernozubow with 10 times original concentration of brilliant green was found suitable for use with Seitz filter enrichment method. Various enrichment methods by filtration, precipitation, and evaporation were examined. Method recommended is filtration through ultrafilter with subsequent backwashing; apparatus required and procedure used for this method are described. Method is suitable for examination of well and surface waters; for examination of sewage, evaporation of 1–2 ml of sample on Wilson-Blair plates is recommended.—*WPA*

The Fate of Virus in River Water and Soil. I. Detection in a Purified Concentrate From River Water. W. O. Gross & G. Kamm. Arch. Hyg. u. Bakt. (Ger.), **137**:237 ('53). With object of developing technique for detection of viruses in river water, model experiments were carried out in which vaccinia virus was added to Tyrode solution in concentration of 100 ID50 per liter. Chick red cells were then added; after shaking, cells were removed by centrifugation and were shown to have adsorbed virus by their ability to infect eggs. In similar experiments PRS virus was added to river water in final concentration which was too low to be detachable by infectivity methods. Bacterial content of mixture was reduced by centrifugation and 0.85% sodium chloride and chick red cells were added; cells were removed by centrifugation, washed, and inoculated into eggs after treatment with penicillin and streptomycin. Virus was recovered in 2 of 6 eggs and was identified in hemagglutination-inhibition tests with specific antiserum; virus could not be detected in eluate of red cells, as it was apparently inactivated by antibiotics. Attempts to recover hemagglutinating virus from 2 samples of river water were unsuccessful.—*BH*

DISTRIBUTION SYSTEMS

The Reduction With Age of the Carrying Capacity of Pipelines. P. Lamont. J. Inst. Wtr. Engrs. (Br.), **8**:53 ('54). This paper, based mainly on report presented by author to 1952 Paris Congress of International Water Supply Assn., summarizes data on number of old pipelines in Britain so that results may be used for design calculations. Author discusses data in relation to theory of roughness as more recently described by Colebrook and White and by himself. He concludes that, for pipes suffering from tuberculation and slime deposits, calculations can usefully be based on assumption that equivalent surface roughness bears linear relationship to time. Author shows that spun-concrete or spun-bitumen linings effectively prevent tuberculation and other effects of corrosion and can be cleaned, for removal of slime and silt, where necessary, without danger of damage by scraper. He presents his results in form of tables and graphs that may readily and quickly be used by designer. He also makes estimate of saving in capital cost due to use of spun-concrete lining rather than dipped coating usually provided.—*PHEA*

Instructions for Protection and Treatment of New and Repaired Water Mains. Sanitarian, **16**:121 (Nov.-Dec. '53). Comprehensive instructions are presented for inspection of materials going into repair of water main, as well as steps taken to insure

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proper disinfection of interior surfaces. Although these instructions are being used by Pacific Gas & Electric Co., they will serve as basis for inspectional followup by sanitarian. Preferred disinfectant for this purpose is chlorine gas or chlorine-yielding compounds such as sodium and calcium hypochlorite. Various methods are suggested for use of chlorine, either with hand pump, portable chlorinator, or direct-feed diffuser. Alternate method is to place high-test calcium hypochlorite in pipe as it is being laid. Relative advantages of each method are also discussed. Tables given which are helpful when using hand pump method of applying chlorine. With aid of these tables, user can calculate proper strength of chlorine solution required, quantity of solution needed for given length of main, and approximate time needed to complete job.—*PHEA*

Radioisotopes for Detecting Leaking Joints in Mains Under Construction. E. A. DORÉ ET AL. J. Inst. Wtr. Engrs. (Br.), 7:160 ('53). Preliminary tests of 2 methods for finding leaking joints in water mains are described. Both methods use radiations from radioisotope Na^{24}, as sodium carbonate (Na_2CO_3), dissolved in water. Main is filled with radioactive solution and pumped up to test pressure for ½ hr. In first method, samples of mud and water from neighborhood of main are brought to surface and examined for activity. In second method, active contents of pipe are moved along to another section of pipe, and Geiger probe is used to check earth surrounding pipe for activity.—*PHEA*

Graphical Analyses of Pressure Surge in Pumping Systems. H. R. LUPTON. J. Inst. Wtr. Engrs. (Br.), 7:87 ('53). Graphical methods most useful in dealing with surge problems in pumping systems are recapitulated. Illustrations are given of their application in typical instances. Object is to insure that any engineer will be able to analyze most surge difficulties which may be met. Graphical illustrations are useful.—*CA*

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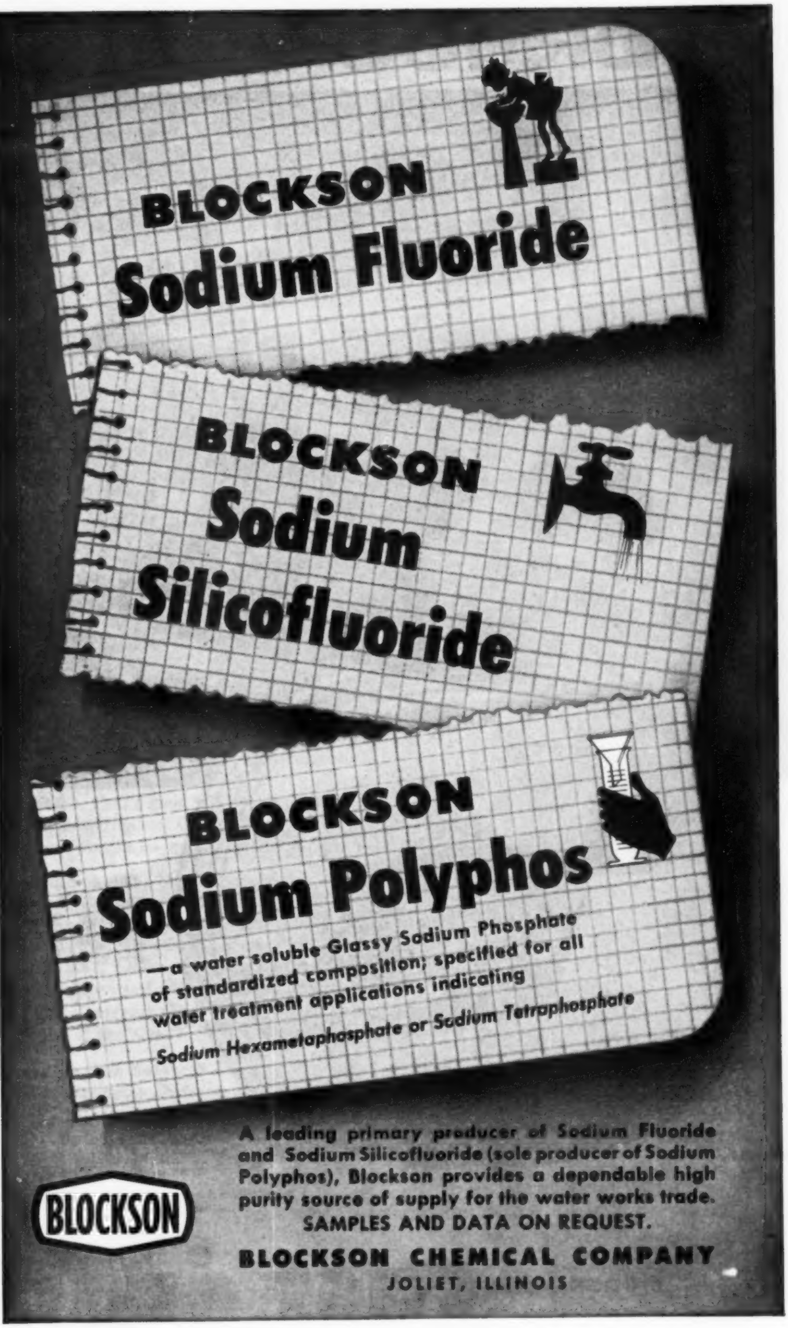
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Submersible Pumps and Motors, Their Construction and Application. W. L. GARDINER. J. Inst. Wtr. Engrs. (Br.), **6**:504 ('52). Submersible motor is British invention. First design was patented in '08. Submersible well pumps are usually of multistage type, with pump located above motor and with suction between them. Submersible electric motor is of squirrel cage induction type, operated on a-c current; d-c motors have invariably proved unsatisfactory. 2 main types differ in manner in which stator surfaces are insulated from cooling liquid. Many types of dielectrics are used, but specially manufactured polyvinyl chloride is best all-purpose material. All submersible motors can be arranged in usual star or delta connections, and sometimes mixed star and delta are used. Bearings are mostly of journal type, either plain or self-aligning. Efficiencies are lower than for surface-type motors; motors are small, as churning losses vary with diameter to fourth power or speed cubed. Cold water usually acts as cooling medium. Electrolytic corrosion is being rapidly overcome. Because most pumps are used in small-diameter wells, pumping unit must be of small diameter with high speeds, about 2,900 rpm. Most manufacturers have standardized on all-bronze and stainless-steel fitted units for motors. Submersible pumping units are made in wide range of sizes from small ones suitable for farms up to installation of four 450-bhp units to dewater mine in Malaya.—*H. E. Babbitt*

Comparative Costs of Elevated and Ground Storage and the Role of the Pressure Tank. J. C. D. TAYLOR. Munic. Util. (Can.), **91**:10:32 (Oct. '53). Storage facilities for communities of up to 2,500 pop. discussed, with particular reference to fire protection. Factors detg. reliability of water systems outlined. Curves given showing fire flow required in relation to pop., storage required to provide 5-hr fire demand, influence of delivery from source on vol. of storage needed, and first and annual costs of steel elev. tanks compared with concrete tanks and pumping equip. Since '46 cost of

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concrete tanks has increased 50%, and that of steel elev. tanks under and over 100,000-gal capac., 100 and 75%, respectively. Pressure tank system has definite place in small systems and should be more widely used in communities of 1,000 or less. Advantages include simplicity and low cost. If tanks of proper size, saving in pumping costs will equal original cost in about 10 yr. Curves included showing size and cost of such tanks for pop. up to 2,500. Disadvantage is absence of storage for fire protection, which may be provided by underground fire tanks fed from distr. system.—*R. E. Thompson*

RADIOACTIVITY

Removal of Radioactive Substances From Water by Biological Treatment Processes. G. E. Eden, G. H. J. Elkins & G. A. Truesdale. Atomics & Atomic Tech., 5:133 (May '54). 2 conventional water and sewage treatment methods were studied to determine their efficacy in removal of radioisotopes: slow sand filtration (water) and activated sludge process (sewage). *Slow sand filtration.* Using sand from mature filters as found in water works in Thames Valley, and raw water from reservoir of same water works, laboratory-size filters were set up for these experiments. Raw water, dosed with fixed amount of radioactive material, was applied to filters at constant rate until activity in effluent became constant. Dosing of raw water was then discontinued, but measurements of activity of effluent were continued, usually for several weeks. Isotopes investigated were: I^{131}, Sr^{90}, Ru^{106}, Ce^{144}, and Pu^{239}. Wide variation in behavior was found, and authors conclude that, as method of treatment purely for removal of activity, slow sand filtration would be suitable only for removal of cerium (of those elements investigated). It would probably be equally effective in removing other rare earths. Process affords little protection against contamination by Ru^{106}, Sr^{90}, and I^{131}. Results of studies are clearly shown graphically. *Activated sludge process.* In addition to ordinary activated sludge derived

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from sewage, 3 sludges derived from synthetic media were used. Radioisotopes investigated were same as above, plus Cs^{134}. Each isotope was added to sample of mixed liquor containing 5,000 ppm of sludge, aerated continuously and sampled at intervals. Each sample was centrifuged immediately and residual activity in clear supernatant determined. Results varied widely, being affected by pH values and other ions in solution. Optimum pH values were quite different for different isotopes. Cerium was most efficiently removed element; cesium or ruthenium, least. Comparison made with results obtained by Ruchhoft for removal of plutonium. Authors conclude that activated sludge method is not as reliable or efficient as chemical methods of treatment for removal of those elements investigated. Results are clearly depicted in graphs.—*PHEA*

Decontamination of Radioactively Contaminated Water by Slurring With Clay. W. J. Lacy. Ind. Eng. Chem., **46**:1061 ('54). In event of atomic, radiological, or hydrogen bomb attack, water supplies may become contaminated with radioactive materials. Clay, because of its adsorptive and ion-exchange capacity, may be effectively used to decontaminate polluted supplies. Results obtained using Oak Ridge, Tenn., tap water, deliberately contaminated with selected radioisotopes and fission product mixtures, indicate clay to be particularly effective for removing cerium 141–144, praseodymium 144, zirconium 95–niobium 95, barium 140–lanthanum 140, and strontium 90–yttrium 90. Clay is less effective for ruthenium 106–rhodium 106, and very poor for iodine 131. Clay dosage of 1,000 ppm appears to be adequate. Increased dosages are wasteful of clay. Varying calcium ion concentration from 0 to 200 ppm has little or no effect on removal of mixed fission products. Elevated pH (over 5) favors removal of mixed fission products. Effectiveness of coagulation and filtration in removing dissolved radioactive contaminants can be materially bettered by preliminary slurring with clay, by addition of clay directly to water during coagulation, along with coagulating chemicals.—*PHEA*

The Sorptive and Zeolitic Properties of Natural Waterborne Silts, With Relation to Their Capacities to Remove, Transport, Concentrate, and Regenerate Radioactive-Waste Components in Natural Waters. Final Report. D. E. Carritt & S. H. Goodgal. Contract AT(30-1)-946, T. O. C. (Oct. '53). Removal of dissolved phosphate, iodide, sulfate, strontium, copper, and iron by suspensions of river and bay sediments, bentonite, fuller's earth, and powdered pyrex glass, under controlled or measured pH, contact time, temperature, concentration of reacting substances, and ionic strength, has been measured. Uptake of phosphorus is maximum in pH range in which the H_2PO_4 ion predominates. Uptake mechanism involving rapid adsorption process and slow diffusion process is described. Strontium, copper, and ferric iron will precipitate from solution as basic salts under appropriate conditions. Added solids act as "sweeper," aiding removal of finely divided precipitate. When conditions for precipitation have not been met, added solids remove these dissolved substances by adsorption and can effect more complete removal than can be achieved by precipitation. There is very little reaction between iodide and suspended solids. Sulfur is adsorbed in pH range favoring formation of HSO_4 ion. Removal of bisulfate by adsorption mechanism during 10° variation in sulfur concentration was demonstrated.—*PHEA*

Observations on the Removal of Radioisotopes During the Treatment of Domestic Water Supplies. II. Radiostrontium. A. L. Downing, A. B. Wheatland & G. E. Eden. J. Inst. Wtr. Engrs. (Br.), **7**:555 ('53). Fate of radioactive isotopes of strontium during treatment of water by conventional process has been investigated on laboratory scale. Only small portion of activity was removed during chemical coagulation as normally carried out. Higher proportion was removed when very large proportion of coagulant was added, and during softening by chemical methods. Softening by ion exchange removed over 97% of activity, higher portion than any other process investigated. When water containing radiostrontium was treated by slow sand filtration, activity of filtered water increased over period of few days to equal that in water before filtration.—*PHEA*

On the Artificial Radioactivity of Rainfall. P. E. Damon & P. K. Kuroda. Nucleonics,

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11:59 (Dec. '53). Radioactivity due to fission products in rain water samples was collected and analyzed from Jun. 5 to Jul. 23, '53, at Fayetteville, Ark. Specific activity dropped during Jun. when tropical marine air mass prevailed, but rose sharply in Jul. when polar continental air mass invaded region. Decay curves showed that fission product in both air masses was probably same age. Measurable activity was recovered from L. Fayetteville water. Estimated that in excess of 10^{-8} curies of fission products fell per square meter in area during period studied. This is less than short-lived natural radioactivity falling during same period.—*PHEA*

Radioactivity of Rivers and Lakes in Parts of Garland and Hot Springs Counties, Arkansas. R. H. Arndt & P. K. Kuroda. Econ. Geol., **48**:551 ('53). Wide range of Rn content in surface waters was noted incidental to studies of Rn in spring and well waters of Hot Springs and Potash Sulphur Springs, Garland County, Ark. Subsequently reconnaissance survey of radioactivity of nearby streams and lakes showed that Rn contents of streams range from 0.0084 to 1.07 millimicrocuries (mμc) per liter of H_2O, and those of lakes range from less than 0.001 to 0.123 mμc. Streams flowing over Ordovician black shales contained avg of 0.275 mμc Rn/l of H_2O. Those flowing over black Stanley shale of Mississippian age contained avg of 0.046 mμc Rn/l of H_2O. Rn content in Potash Sulphur Creek, where it flows over uranium-bearing rocks of Potash Sulphur Springs syenite complex, ranged from 0.09 to 3.16 mμc/l of H_2O. Ground water in drill hole in uranium-bearing rock contained avg of 58.75 mμc/l of H_2O. Waters from small springs were shown to lose as much as 41.3% of total Rn content in first 4' of surface flow below point of emergence. Methods of Rn determination in field are believed applicable to prospecting for low-grade uraniferous deposits, especially in black shale areas, in areas of heavy overburden, and in areas of saturation by ground

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water where ordinary detection devices may be somewhat limited.—*PHEA*

Maximum Permissible Concentration of Radioisotopes in Food, Water, and Air and Maximum Permissible Equilibrium Amount in the Body. K. Z. MORGAN. Acta Radiol., **41**:30 (Jan. '54). Gives values of max. permissible body burden, Q, and max. permissible concentration, MPC, in air and water of 70 radioisotopes. These values are published in handbook prepared by National Committee on Radiation Protection. Some values chosen are based on human experience, but most are calculated using data from animal experiments. Value of Q is considered to be microcuries of radioisotope deposited in total body that will deliver 0.3 rem (roentgen equivalent man) per week to critical organ—i.e., one receiving radioisotope that results in greatest overall damage to body. MPC values are concentrations of radioisotopes in air or water that, if used exclusively for extended time, will lead to accumulation, Q, in body. In most instances considered, equilibrium is reached in few weeks. MPC values for air and water to be used in emergency are also given. Large dose of ionizing radiation is delivered to tissue in close proximity to airborne particle of high specific activity that becomes fixed in living tissue. In setting MPC values for air, one would like to know if such localized radiation increases probability of tumor occurrence.—*PHEA*

Health Safety Considerations in the Disposal of Radioactive Wastes. F. WESTERN. Am. Indus. Hyg. Assn. Quart., **14**:195 (Sep. '53). Extent to which radioisotope may safely be released into natural environment depends upon rate of intake, averaged over appropriate periods of time, of radioisotope by persons working or living in affected area. Under many conditions, large quantities of radioactive material may be released with certainty that resultant rates of intake will be far less than maximum permissible values. Release under conditions in which average resultant concentrations in air, water, and food supplies may not be readily measurable or are not subject to continuous control will, in general, require either higher degree of confidence in original estimates of safe quantities or application of larger margin of safety. Ranges of quantities of material, rates of release, or concentrations at point of release which will be safe under various sets of conditions are so wide that it is impossible to determine realistic upper limits except by evaluation of conditions which actually exist in any particular instance. Health safety standards should always be based upon resultant rates of human intake rather than upon arbitrary limitation of quantities released.—*PHEA*

Survey of Radioactive-Waste Disposal Practice. H. S. MILLER, F. FAHNOE & W. R. PETERSON. Nucleonics, **12**:68 (Jan. '54). Report on results of questionnaire survey of waste disposal practices of 1,027 radioisotope users. Questions were asked regarding quantity and type of wastes, activity concentration in wastes, method and cost of disposal, etc. 92% respondents indicated waste production to be less than 2 gpd. 60% indicated activity concentration in wastes as less than one microcurie per gallon. 41% disposed of wastes by dilution and discharge to sewers. 69% indicated negligible expense involved in waste disposal. Additional 19% spent less than $100 annually, 10% spent from $100 to $1,000 annually, and remaining 2% spent from $1,000 to $6,000 per year to dispose of radioactive wastes.—*PHEA*

POLLUTION CONTROL

Toxicity of Various Refinery Materials to Fresh Water Fish. H. TURNBULL, J. G. DEMANN & R. F. WESTON. Ind. Eng. Chem., **46**:324 ('54). Because killing of fish is most obvious evidence of injury to aquatic life, toxicity of various chemicals and materials to fresh-water fish commonly known as bluegill sunfish was investigated. Practical use of results obtained requires considerable caution because of influence of local conditions on toxicity of specific material to fish. Nevertheless, data obtained from procedures developed afford best means known at this time for determining probable toxic effects on fish. After permissible concentrations of toxic materials have been determined by bioassay procedures, more simple and less costly chemical test may be used for control purposes.—*PHEA*

Measurement of the Toxicity of Substances to Fish. D. W. M. HERBERT. J. & Proc. Inst. Sew. Purif., Part 1, p. 60 ('52).

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In previous work on this subject, different conditions and methods of interpreting results have been used. Fixed-volume tests are generally unsuitable when purpose of test is to assess probable effect of toxic agents on fish in river. Water Pollution Research Lab. has devised continuous-flow apparatus. Stream of water is aerated and pumped to constant-level tank, from which it flows at about 2 l per minute through controlling orifice plate to mixing device where poison is added at constant rate. Stream of poisoned water is retained for time in delay tank, and then flows to test tank where its temperature is controlled. This apparatus is rather too costly for routine testing, so standardized toxicity tests are made in fixed volumes of solution, limiting variations in environment. Account is given of these environmental variations, and methods of interpreting results of tests are summarized. Fish are very variable in their response to poisons, as are all living organisms; therefore, more fish used, more accurate will be estimate. Example given of effect of cyanide on rainbow trout, and results interpreted.—*PHEA*

Persistence of Pyridines Bases in Polluted Water. M. B. Ettinger, R. J. Lishka & R. C. Kroner. Ind. Eng. Chem., **46**:791 ('54). Pyridine and 3- and 4-picoline are subject to biological attack by microorganisms occurring in surface waters. When good seed is present, such attack may be rapid. Organisms in sewage attacking pyridine apparently are not numerous. Organisms attacking 4-picoline apparently were absent in 4 sewage samples. Pyridine has very definite BOD, as it can be aerobically attacked in dilute solutions by microorganisms. However, BOD of compound may not be observed unless seed contains organisms which do attack compound. Tests may not reveal true BOD of chemical wastes. Load exhibited in stream after dilution is basic measure of pollutional characteristics of waste.—*PHEA*

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That rugged old pump of yours may not be the bargain that it seems. Let's do some arithmetic. If the efficiency of the old pump is 75% vs. the 85% efficiency of the new pump, you are paying more to keep it than you would to replace it. That's because a new unit of equivalent output uses less power. Thus it soon saves its own cost—then begins to pay dividends.

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(Continued from page 86)

Factors Affecting the Formation and Oxidation of Sulfides in a Polluted Estuary. A. B. WHEATLAND. J. Hyg. (Br.), **52**:194 ('54). Factors affecting formation and destruction of sulfide in Thames Estuary discussed. Measurements of oxidation-reduction potentials show that effect of oxygen in water on condition in deposits of mud is limited to surface layer. Rate of formation of sulfide increases with temperature, doubling approximately for each 10°C rise. Reduction of sulfate to sulfide will occur at temperatures as low as 5°C, but even at 25°C is inhibited by traces of DO. Mud in suspension in estuary can produce as much sulfide as compact layers of similar mud which might be more anaerobic. Oxidation of sulfide in Thames Estuary is shown to be of purely chemical nature; rate of oxidation, when oxygen is present, is increased by presence of suspended matter and iron. In Thames Estuary, however, rate is limited by rate at which oxygen enters water.—*PHEA*

Recharge and Travel of Pollution. ANON. Johnson Natl. Driller J., **26**:5 (Jan.–Feb. '54). Univ. of California has issued progress report on "Investigation of Travel of Pollution," dealing with university research project for Calif. Water Pollution Control Board. Many aquifers are being overpumped so that they are threatened with salt water intrusion, or capacity is decreasing so that some irrigated lands may go dry again. Topics under study were: [1] travel of pollution with ground water; [2] use of recharge; [3] operating and maintaining recharge wells; [4] economic aspects of recharge. One 12″ recharge well and eighteen 6″ observation wells located 10′–500′ from recharge well were drilled through confined aquifer averaging 3½′ in thickness. Specific yield of aquifer was 1.2 gpm/ft of drawdown. Aquifer took recharge of about 0.9 gpm/ft of head, which is rate of 13,000 gpd/ft of thickness. Rate of travel of pollution is more rapid in direction of normal ground water movement. Clogging of re-

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charge well screen by iron compounds and clay dispersion caused by recharging with water of different chemical characteristics from that of water existing in aquifer was one difficulty. Conclusions are: [1] recharge is possible; [2] pollution travels farthest in direction of ground water movement; [3] bacterial pollution does not travel as fast or as far as chemical pollution; [4] recharge wells require special design and operation consideration; [5] dispersible clays in recharge formation may cause clogging. —*PHEA*

Stream Pollution. Ocean Outfall Studies at San Diego. F. J. Kersnar & D. H. Caldwell. Sew. Ind. Wastes, **25**:1336 ('53). Studies of ocean disposal of sewage demonstrated suitability of disposing of sewage of San Diego County into Pacific Ocean. Studies of other phases of sewerage requirements of county indicated economy of such disposal. Based on these findings, board of engineers recommended construction of primary sewage treatment plant at Point Loma, with discharge of effluent to Pacific Ocean 7,500′ off shore in 125′ of water. Initially plant would serve more than 1,000,000 persons, and ultimately more than 2,500,000 persons.—*PHEA*

Process Engineering in Stream Pollution Abatement. A. N. Heller & M. E. Wenger. Sew. Ind. Wastes, **26**:171 ('54). In manufacture of synthetic phenol by sulfonation process, liquid (process) wastes were essentially eliminated by application of principles of process engineering. Economics of this approach, per se, were justifiable; that is, total cost of project ($100,000) compares with return of $112,000 per year. Major phase of overall stream pollution abatement program at Frankford works has been completed, particularly as it relates to discharge of phenolic compounds. Improved process for boilout of still-bottom synthetic-phenol plant permitted elimination of 64% of phenolics from plant wastes. Extensive laboratory, pilot, and plant studies enabled economical recovery of major chemical values: capital investment of $35,000 returned $75,000 per year. Stepwise approach with regard to both technology and time of accomplishment was productive of stream pollution abatement and improvement in operations of plant.—*PHEA*

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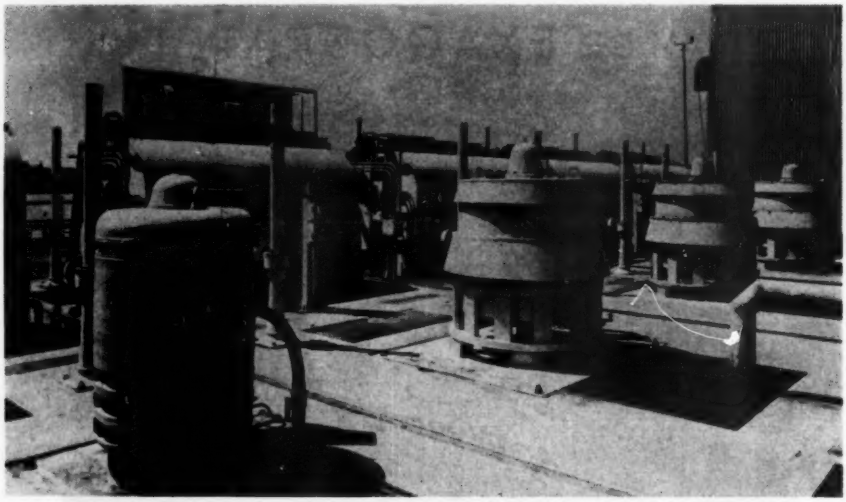

It takes 230 mgd of Delaware River water, 5 mgd of potable ground water, and 15 mgd of specially treated high-quality water in three separate systems to enable US Steel's Fairless Works at Fairless Hills, Pa., to produce approximately 2,200,000 tons of carbon-steel ingots per year. Even more complex than the separate piping and supply systems, however, is the provision for standby power and pumping, for failure of water supply would mean not only interruption of operations but also severe damage to the open hearth and blast furnaces. Part of the outdoor pumping station is shown above, with four of a battery of Fairbanks-Morse motors, used to drive the low-lift pumps, in the foreground. In the rear are the drives for the travelling intake screens.

As impressive as the water supplies and the steel works itself may be from a technological standpoint, there is one aspect of the plant which, from the point of view of society as a whole and the water works man in particular, is still more impressive. And that is the fact that the entire effluent of the three water systems is treated and returned to the river in as good sanitary condition as when it was taken out. We are told that the Fairless Works produces carbon steel, but, nontechnically speaking, this steel is stainless!

Ross Barrett has joined Byron Jackson Co. to head an expanded department responsible for public relation, advertising, and sales promotion, as well as market study.

A check-up service for domestic water softeners is being offered without charge or obligation by Elgin-Refinite, Div. of Elgin Softener Corp., Elgin, Ill. Prompted by a survey which showed that many softeners were operating below normal efficiency, the company will undertake to have a field engineer check equipment and report findings to the owner in a "Softener Efficiency Cost Analysis" report.

CHANGES IN MEMBERSHIP

MEMBERSHIP METER
10|2|0|7
OCT | 1 | 1954
AMERICAN WATER WORKS ASSOCIATION

NEW MEMBERS

Applications received Sep. 1–30, 1954

Anderson, Fritz A., Plant Supt., Otter Tail Power Co., Box 218, Crookston, Minn. (Oct. '54) *MP*

Anderson, Robert A., Administrative Asst. & Personnel Officer, City of Toledo, Div. of Water, 565 N. Erie St., Toledo, Ohio (Oct. '54) *MD*

Atherholt, John B., Sales Engr., Fluid Controls Co., Inc., 5150 Ridge Ave., Philadelphia 28, Pa. (Oct. '54) *PD*

Atwater, J. R., Engr., City Water Works, 1112 Appleton Ave., Macon, Ga. (Oct. '54) *MD*

Barnes, Bruce, Dist. Repr., Darling Valve & Mfg. Co., Hotel Warren, Indianapolis, Ind. (Oct. '54) *MRPD*

Bird, George C., Sales Engr., Wallace & Tiernan Inc., Box 178, Newark 1, N.J. (Oct. '54) *MRPD*

Blumel, Herman F., Jr., Standards Engr., Factory Mutual Eng. Div., 52 Vanderbilt Ave., New York 17, N.Y. (Oct. '54) *RD*

Brown, George W., Director, Water & Street Div., Martinsville, Va. (Oct. '54) *MPD*

Brumbaugh, Allen J.; *see* Yardley (Pa.) Water & Power Co.

Burke, William C., Jr., San. Engr. Assoc., City Health Dept., 118 Temple St., Los Angeles, Calif. (July '54) *MP*

Burn, Paris R., Sr., General Contractor, 205–208 Carver Bldg., Las Cruces, N.M. (Oct. '54) *M*

Burns, Walter J., Civ. Engr. Assoc., Dept. of Water & Power, 207 S. Broadway, Los Angeles, Calif. (Oct. '54) *MRD*

Burr, George D., Asst. Mgr. & Chief Engr., Water Dept., 425 Mason St., San Francisco, Calif. (Oct. '54) *MR*

Bush, Vern; *see* Bush, Vern, Co.

Bush, Vern, Co., Vern Bush, Owner, 796 Howard Ave., Holland, Mich. (Assoc. M. Oct. '54)

Castle, Richard L., Asst. City Engr., 13600 Oak Park Blvd., Oak Park, Mich. (Oct. '54)

Castorina, Anthony R., Chemist, Bridgeport Hydraulic Co., 835 Main St., Bridgeport, Conn. (Oct. '54)

Chapman, Matthew M., Sales Engr., Grinnell Co., Inc., 240 N. Highland Ave., Atlanta, Ga. (Oct. '54) *PD*

Chu, James, Civ. Eng. Asst., Dept. of Water & Power, 316 W. 2nd St., Los Angeles, Calif. (July '54) *MP*

Clark, John W., Asst. Prof., Civ. Eng., New Mexico A&M, State College, N.M. (Oct. '54) *RPD*

Cox, S. M., Supt. of Water & Light, Box 245, Sandersville, Ga. (Oct. '54) *MRP*

Crist, Chester E., Civ. Engr. Assoc., Div. of Water, 2986 Neil Ave., Columbus 2, Ohio (Oct. '54) *MP*

Cuskelly, Donald F., City Engr., Dickinson, N.D. (Oct. '54) *PD*

Darby Products of Steel Plate Corp., J. D. Haynes, Engr., 1st & Walker Sts., Kansas City 15, Kan. (Assoc. M. July '54)

de Paiva Castro, Paulo, Engr., 428 Rua Piaui, Apto. 66, Sao Paulo, S.P., Brazil (Oct. '54)

Dowdell, Marc P., Pres., Yardley Water & Power Co., 50 W. College Ave., Yardley, Pa. (Oct. '54) *M*

Drynan, Walter R., Research Engr., Univ. of Texas, 1900 Whitis, Austin 5, Tex. (July '54)

Eddy, Edwin J., Asst. Secy., Lock Joint Pipe Co., 3051 Wyoming Ave., Dearborn, Mich. (Oct. '54) *D*

Eiffert, William T., Water Works Engr., Dept. of Water, 3rd at Ludlow, Dayton, Ohio (Oct. '54) *MRPD*

Evans, Richard P., Field Engr., Infilco Inc., 10316 Manorford Rd., Cleveland 30, Ohio (Oct. '54) *P*

Fairbrother, Fred H., Asst. Supervisor, City of Berkley, 2936 Phillips, Berkley, Mich. (Oct. '54) *M*

Farris, Clyde A., Jr.; *see* Water Services

Fisher, Waldo V., Village Engr., Sheridan, Mich. (Oct. '54) *M*

Florer, Robert S., Partner, Lawrence, Fogg & Florer, 4730 Palm Ave., La Mesa, Calif. (Oct. '54)

Fortenberry, H. C., Water Supt., 643 S. 3rd, Durant, Okla. (Oct. '54)

Franklin, C. M., Water Supt., Warner Robins, Ga. (Oct. '54) *MP*

Froelich, Carl T., Civ. Eng. Asst., Dept. of Water & Power, 207 S. Broadway, Los Angeles 12, Calif. (July '54) *MD*

Glenn, Thomas R., Jr., Asst. Prof., Civ. Eng. Dept., Rutgers Univ., New Brunswick, N.J. (Oct. '54) *MRP*

Growdon, H. C., Supt., Water Works, Portsmouth, Ohio (Oct. '54)

Gunnarson, LeRoy; *see* Service Hardware & Implement Co.

Hach, Clifford C.; *see* Hach Chem. Co.

Hach Chem. Co., Clifford C. Hach, Pres., Ames, Iowa (Assoc. M. July '54)

Harper, Willard, Chief Chemist & Water Treatment Supervisor, 3057 Palmetto St., Columbus, Ohio (Oct. '54) *P*

Hartman, Ralph L., Supt., Water Works, 109 S. State St., Caro, Mich. (Oct. '54) *MR*

Hawk, Howard E., Supt., Board of Public Affairs, 318 Herrick Ave. E., Wellington, Ohio (Oct. '54)

Hawley, William C., Jr., Sales Engr., Electro Rust-Proofing Corp., 647 Cascade Rd., Pittsburgh 21, Pa. (Oct. '54) *PD*

Haynes, J. D.; *see* Darby Products of Steel Plate Corp.

Hensley, Ray G., Chief Chemist, City of Fort Lauderdale, 630 S.W. 11th Court, Fort Lauderdale, Fla. (Oct. '54)

Heldt, Carl A., Vice-Pres., Heldt-Monroe Co., 201 N. Main St., Evansville, Ind. (July '54) *RP*

Henry, Edouard, Cons. Engr., 2453 E. Sherbrooke St., Montreal, Que. (July '54) *MRPD*

Hernly, Miles A., Partner, Hernly Brothers, Parker, Ind. (Oct. '54) *RPD*

Holl, Alfred T., County San. Engr., 933 Market Ave., N., Canton, Ohio (Oct. '54) *RD*

Hoover, Rodney, Civ. Engr., Box 541, Muskegon, Mich. (Oct. '54) *D*

Houghn, Marshall, Asst. Supt., Div. of Water, City Hall, Columbus, Ohio (Oct. '54) *MP*

Huntsville Water Works Utility Board, K. A. Woltersdorf, Gen. Mgr., Huntsville, Ala. (Corp. M. Oct. '54)

Jensen, William L., Jr. Civ. Engr., City of Hawthorne, 200 W. 126th St., Hawthorne, Calif. (Oct. '54) *D*

Johnson, Edward L., Water Plant Supt., Murfreesboro, Tenn. (Oct. '54) *RP*

Jolly, Jim, Sales Repr., Wolverine Tube Div., Calumet & Hecla Inc., Suite 1212 High & Long Bldg., Columbus, Ohio (Oct. '54) *D*

Kaser, Kent S., San. Engr., Clyde E. Williams & Assocs., 312 W. Colfax Ave., South Bend, Ind. (Oct. '54)

Kilgore, James S., Constr. Foreman, Water Works, 644 Main St., Macon, Ga. (Oct. '54) *MD*

Kipp, Kendall, Gen. Economist, Missouri-Souris Projects Office, Bureau of Reclamation, Box 1050, Bismarck, N.D. (Oct. '54) *R*

Koser, Kent S., San. Engr., Clyde E. Williams & Assoc., 312 W. Colfax Ave., South Bend, Ind. (Oct. '54) *RPD*

Krey, Ben H., Partner, Krey & Hunt, 250 E. 43rd St., New York 17, N.Y. (Oct. '54) *PD*

Krusen, Leslie C., Jr., Sales Repr., US Pipe & Foundry Co., Peoples Gas Bldg., Chicago, Ill. (Oct. '54) *R*

Lamb, Fred, City Engr., City Hall, La Grange, Ga. (Oct. '54) *MP*

Leaman, Harold V., Secy.-Mgr., Summit Water & Supply Co., 5401 E. 104th St., Tacoma 44, Wash. (Oct. '54) *MD*

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Lever Brothers Co., Research & Development Div., (Miss) Eleanor M. Rice, Research Librarian, 45 River Rd., Edgewater, N.J. (Corp. M. Oct. '54)

Lewis, Jackson M., Civ. Eng. Assoc., Dept. of Water & Power, Rm. 826, 316 W. 2nd St., Los Angeles, Calif. (Oct. '54) *M*

Lindsey, James A., Engr., Hutchinson, Minn. (Oct. '54) *R*

Lockhart, W. B., Chemist, Water Works, City Hall, Fostoria, Ohio (Oct. '54) *P*

Los Angeles Water Softener Co., Inc., Eugene Schmidt, Tech. Director, 1723 Riverside Dr., Los Angeles 31, Calif. (Assoc. M. Oct. '54)

Louden, Lester L., Chief Chemist, Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '54) *P*

Lund, LeVal, Civ. Engr. Assoc., Dept. of Water & Power, Water System, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '54) *D*

Lunsford, Jesse V., Asst. Prof. & Asst. San. Engr., Washington State College, 100 Scott Pl., Pullman, Wash. (Oct. '54) *P*

Macy, William E., Sewer Supt., 1012 Ottawa St., Dayton 2, Ohio (Oct. '54)

Marlin, John D., Jr., Mgr., Light & Water Dept., 301 E. Market St., Athens, Ga. (Oct. '54) *M*

McDonald, H. Frank, Partner, Scott, McDonald & Harrell, 3400B Camp Bowie Blvd., Fort Worth, Tex. (Oct. '53) *MRP*

McElroy, John Luther, Jr., Chemist, Water Dept., Meridian, Miss. (Oct. '54) *RP*

McKay, Wilbur S., Jr., Special Repr., Johns-Manville Sales Corp., 1530 Guild Hall Bldg., Cleveland, Ohio (Oct. '54) *D*

Mills, John R., Cons. Geologist, R. E. Chapman Co., Dorset, Vt. (Oct. '54) *R*

Millwee, Robert M., Jr., Cons. Engr., 5403 Kirby Dr., Houston, Tex. (Oct. '54) *RPD*

Murphy, Marie A., Chief Analyst, Lab., Filtration Div., Filtration Plant, Pittsburgh 15, Pa. (Oct. '54) *MP*

Murray, W. Bruce, 5360 El Jardin St., Long Beach 15, Calif. (Oct. '54)

Nickles, Marshall J., General Foreman, Pacific Gas & Elec. Co., 23 N. Washington, Sonora, Calif. (Oct. '54) *MRPD*

Nielsen, Warren V., Asst. Civ. Engr., Greenfield Construction Co., 16596 Greenfield Rd., Detroit 35, Mich. (Oct. '54) *D*

Norton, Robert D., Branch Mgr., Harris Pump & Supply Co., 922 Quarrier St., Charleston, W.Va. (Oct. '54) *P*

Oals, Wendell M., Sr., Resident Engr., Robert & Co., 5203—12th St., Tampa 3, Fla. (Oct. '54) *M*

O'Maley, Andrew T., Asst. Water Works Operator, Water Works, 203 Riley St., Loogootee, Ind. (July '54) *MRPD*

Ortman, Richard, J. B. Ortman & Sons, Well Drillers, R.R. 1, Kokomo, Ind. (Oct. '54) *R*

Patterson, John L., Supt., Water Works, Clayton, Ga. (Oct. '54) *MP*

Paul, Merle R., State Mgr., Armco Drainage & Metal Products, Inc., 726 Atlas Bldg., Columbus, Ohio (Oct. '54) *RD*

Paulson, Everett, J. L., Chemist, Fridley Softening Plant, 43rd & Marshall St., N.E., Minneapolis, Minn. (July '50)

Pearson, Gordon G., Civ. Engr., Water Works Branch, City Engrs. Dept., Old Drill Hall, Cape Town, South Africa (Oct. '54) *MRPD*

Pedersen, C. H., Div. Gas Supt., Pacific Gas & Elec. Co., 161 Main St., Salinas, Calif. (Oct. '54) *D*

Petska, Leonard J., Asst. Supt., Water Works, Cedar Rapids, Iowa (Oct. '54) *MPD*

Pond, Murray D., Mgr., Palmdale Irrigation Dist., 816 E. Ave. Q-7, Palmdale, Calif. (Oct. '54) *MPD*

Price, James W., Civ. Eng. Asst., Dept. of Water & Power, 316 W. 2nd St., Los Angeles, Calif. (Oct. '54) *D*

Rateuke, John H., Water Supt., Washington, Kan. (July '54)

Ree, William R., Jr., San. Eng. Assoc., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '54) *P*

Reedy, Charles E., Dist. Mgr., Cathodic Control Corp., 1341 Pursell Ave., Dayton 10, Ohio (Oct. '54) *MD*

Reynolds, G. R., Sales Engr., Rockwell Mfg. Co., 1922—19th Ave., S., Nashville, Tenn. (Oct. '54)

Rhodes, Raymond E., Southeastern Sales Mgr., Jones Chemicals, Inc., 2365 Dennis St., Jacksonville, Fla. (Oct. '54) *P*

Rice, Eleanor M. (Miss); *see* Lever Brothers Co.

Riddle, Roland, 2017 Meadow Valley Terr., Los Angeles 39, Calif. (Dec. '48)

Roberts, George C., Chem. Engr., Water Works, Macon, Ga. (Oct. '54) *RP*

Robinson, L. R., Jr.; *see* Robinson Pipe Cleaning Corp.

Robinson Pipe Cleaning Corp., L. R. Robinson Jr., Exec. Vice-Pres., Box 300, Canonsburg, Pa. (Assoc. M. July '54)

Rodriguez, Edward C., 1106 S E St., Harlingen, Tex. (Oct. '54)

Rose, Thomas Allan, Dist. Sales Mgr., Chlorinator Div., Fischer & Porter Co., 7805 S. Western Ave., Chicago 20, Ill. (Oct. '54) *P*

Saylors, Roy A., Dist. Repr., Worthington-Gamon Meter Div., 1426 Trenton, Denver, Colo. (Oct. '54) *D*

Schmidt, Eugene; *see* Los Angeles (Calif.) Water Softener Co.

Service Hardware & Implement Co., LeRoy Gunnarson, Partner, 1545 Bay St., Tacoma, Wash. (Assoc. M. July '54)

Sharpshair, E. A., Water Works Supt., 210 S. Wayne, Lockland, Ohio (Oct. '54) *MPD*

Shugart, Marion L., Trustee, Water Dept., 35 N. Main St., Council Bluffs, Iowa (July '54) *M*

Simons, Ralph L., Supt., Water Works, Thomson, Ga. (Oct. '54) *MP*

Sloan, Dale E., Operator, Water Plant, Dept. of Munic. Service, Wyandotte, Mich. (Oct. '54) *MRP*

Smith, George H., Sales Engr., Calgon Inc., Box 1346, Pittsburgh, Pa. (Oct. '54) *P*

Spencer Munic. Utilities, Glen V. Yarger, Mgr., 708 Grand, Spencer, Iowa (Corp. M. Oct. '54) *MRPD*

Stanley, Frederick L., Supt., Water Works, City Bldg., Redkey, Ind. (Oct. '54) *MP*

Steen, Charles W., Supt., Water Dept., Wellsville, Kan. (July '54) *MR*

Tennant, James O., City Mgr., 33312 Grand River, Farmington, Mich. (Oct. '54) *MRPD*

Thomas, L. B., City Clerk, Carthage, Tenn. (Oct. '54)

Trotter, Melvin L., Filter Plant Operator, Water Dept., Coffeyville, Kan. (Oct. '54) *MRP*

Turner, Joseph P., Sales Engr., Graver Water Conditioning Co., 911 Oakridge Ave., Royal Oak, Mich. (Oct. '54) *MP*

Tysinger, Henry E., Water Works Operator, Thomasville, N.C. (July '54) *MP*

Uman, George A., Physicist, Dept. of Water & Power, San. Eng. Div., Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '54) *RP*

Wagner, Edward B., Ohio Sales Mgr., Diehl Pump & Supply Co., Inc., Roselawn Center Bldg., Rm. A-6, Cincinnati 37, Ohio (Oct. '54) *R*

Warner, Arthur L., Supt., Low Service Pumping Sta., Div. of Water, Toledo, Ohio (Oct. '54) *D*

Water Services, Inc., Clyde A. Farris Jr., Pres., 229 Dale Ave., Knoxville, Tenn. (Assoc. M. July '54)

Weissman, Seymour, Pres. & Gen. Mgr., S. Weissman Excavating Co., Inc., 15496 Telegraph Rd., Detroit 39, Mich. (Oct. '54) *D*

Whaley, James R., Supt. Water Works, Sparta, Ga. (Oct. '54) *MPD*

Wilson, Gustave A., Dist. Supt., Los Angeles Dept. of Water & Power, 950—1st St., San Pedro, Calif. (July '54) *M*

Wintz, William A., Jr., Assoc. Prof., Civ. Eng., College of Eng., Louisiana State Univ., Baton Rouge, La. (Oct. '54) *PD*

Woltersdorf, K. A.; *see* Huntsville (Ala.) Water Works Utility Board

Wortman, Carl, Supt., Water Plant, Water Dept., Chanute, Kan. (July '54) *MP*

Yardley Water & Power Co., Allen J. Brumbaugh, Supt., 50 W. College Ave., Yardley, Pa. (Corp. M. Oct. '54) *MRPD*

Yarger, Glen V.; *see* Spencer (Iowa) Munic. Utilities

Service Lines

Gate valves from 2 to 60 in. in size are featured in a 12-page booklet, Bul. A, of Rensselaer Valve Co., Troy, N.Y. A wide variety of end connections are available for coupling with various types of pipe.

New pipe cutters for 2½- to 12-in. pipe are featured in catalog sheet HCW of the Reed Mfg. Co., Erie, Pa. The hinged yoke construction and use of four cutting wheels makes it possible, according to the company, to cut 8-in. steel pipe in less than 5 min.

Remote-reading liquid level gages are described in Catalog 246 of Jerguson Gage & Valve Co., 80 Fellsway, Somerville, Mass. The gages feature Truscale, a convex scale which is readable from the sides as well as the front.

"Your printing costs are as follows," cheerily announces Regina Services Corp., 847 Lexington Ave., Brooklyn 21, N.Y., and in the course of a brisk little catalog offers quotations on a multitude of standardized sizes and types of printing jobs, including offset reproduction, letterheads and envelope printing, catalog imprinting, and the like.

Fischer & Porter Co. instruments, chlorinators, and other equipment are shown in Catalog 1, available from the firm at 172 Jacksonville Rd., Hatboro, Pa. Among products described are flow meters and regulators, instruments for the indication of liquid level, pressure, temperature, density, and viscosity, and industrial glass products such as precision bore tubing.

"Turbine Pumps for Industry," an 8-page booklet (No. 735–1) of A. O. Smith Corp., 5715 Smithway St., Los Angeles 22, Calif., describes characteristics, construction, and typical installations of the latest line of pumps offered by the company's Hydraulic Div.

Check valves are the subject of a folder distributed by Williams Gauge Co. Inc., 1620 Pennsylvania Ave., Pittsburgh 33, Pa. Entitled "Williams-Hager Flanged Silent Check Valves," the bulletin, No. 654, describes both center-guided and globe type models.

Centrifugal pumps of Worthington Corp., Harrison, N.J., are listed in Bul. W–395–B2, just issued. The self-priming pumps are frame mounted, have capacities up to 550 gpm, heads to 140 ft, and sizes from 1½ to 4 in.

Section Meetings

New York Section: The New York Section had a record attendance of 420 at its annual fall meeting at Montauk Manor, Montauk, L.I., on September 9–10.

George E. Symons, consultant and technical editor of Larchmont, opened the meeting on Thursday with an interesting talk on "The Distribution System," touching briefly on reservoirs, transmission mains, valves, hydrants, service meters and operating problems. Arthur T. Luce, vice-president of the New York Water Service Corp., continued this discussion with an excellent paper on "Sizing of Water Mains," in which he urged that future growth programs be carefully studied before mains are installed, taking into consideration industrial expansion, fire flow needs, and necessary pressures.

R. M. Leggette, consulting geologist of New York, talked about the cultural history, political subdivision, and topography of Long Island, and J. E. Upson, district geologist of the US Geological Survey, discussed the source of ground water on Long Island, water-bearing aquifers, and precipitation.

N. F. Fenn, general manager of the Suffolk County Water Authority, reported on "The Operation of a Water Authority." Edward J. Kilcawley, professor of sanitary engineering, Rensselaer Polytechnic Inst., presented a paper on "Measurement of Atomic Fallout in Reservoirs," describing tests and results made in the Troy, Schenectady, and Albany area (*see* this issue, p. 1101). Arthur H. Johnson, associate engineer of the State Water Power and Control Com., brought the afternoon session to a close with a paper on "Conservation of Water on Long Island," covering the use and advantages of diffusion wells and recharge basins.

Cocktails, served through the courtesy of the Water and Sewage Works Manufacturers Assn., preceded the annual banquet at which Perry B. Duryea, conservation commissioner, State of New York, spoke about the history of Montauk and surrounding areas.

The Fred Astaire Dancers entertained and conducted a dance contest. Mrs. Frank Szuniewicz of Buffalo displayed an outstanding talent for the polka, winning the ladies prize, and Mr. Dan S. Vetromile, of the A. P. Smith Co., took honors for jitterbugging.

The Round Table Conference on Friday morning, led by Nelson M. Fuller, general superintendent of Batavia, included discussions of water hammer, public relations techniques, and a comparison of the state pension system with social security. The meeting was a great success, and excellent recreation facilities were provided by Montauk Manor.

KIMBALL BLANCHARD
Secretary-Treasurer

Kentucky-Tennessee Section: The joint meeting of the Kentucky-Tennessee Section AWWA with the Kentucky-Tennessee Industrial Wastes and Sewage Works Assn. in Nashville, Sep. 20–22, 1954, set a new record for registrations, with 294 attending. This number in-

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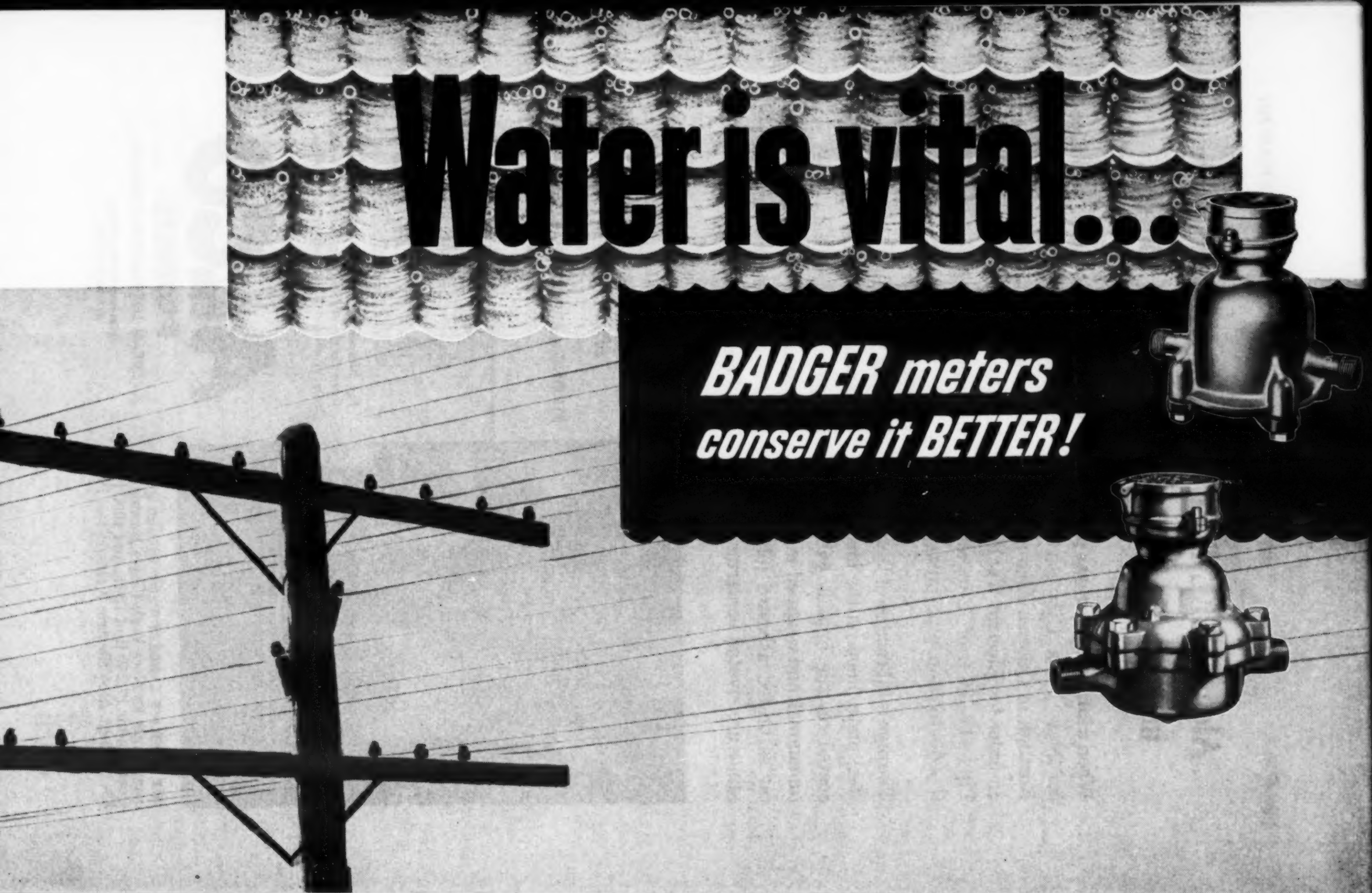
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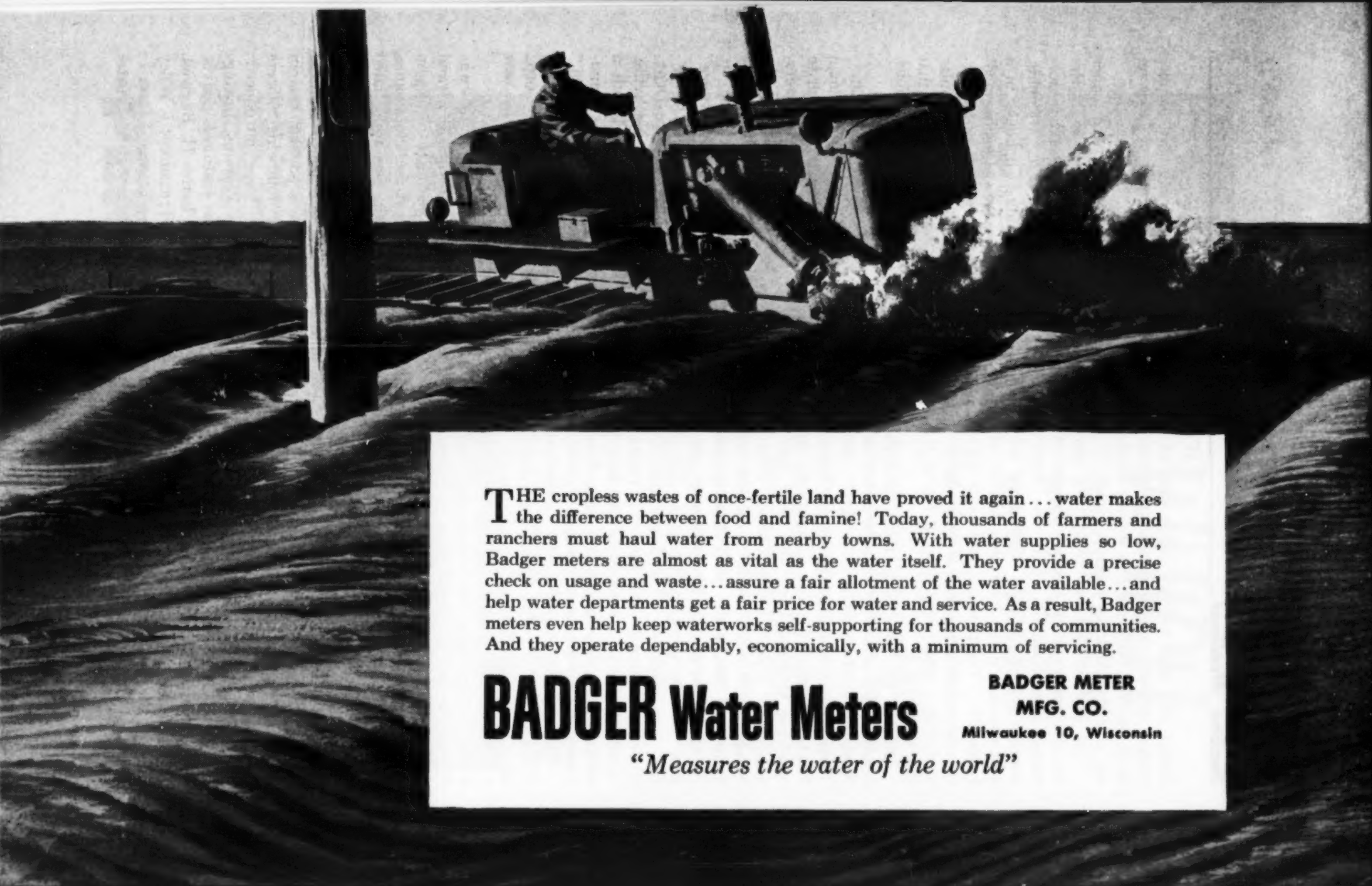

Section Meetings

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cluded 233 men and 61 ladies and exceeded the previous record registration by about 50. Headquarters for the meeting was the Andrew Jackson Hotel.

The joint session on the opening day was greeted by Gayle Gupton, director of finance for Nashville, who was representing the mayor. A response to the welcome was given by Henry Gerber of Louisville. The parent associations were represented by President Dale L. Maffitt of AWWA and Vice-President David B. Lee of FSIWA.

During the afternoon those present heard a discussion on "Construction of Nashville's Interceptor Sewers" by Thomas B. Lee, of the Nashville, Tenn., Dept. of Public Works. "Experience in Studying Organic Taste and Odor Substances in Water, Using Carbon Filter Sampling Methods" was presented by Frank M. Middleton, US Public Health Service, Cincinnati. The afternoon session was concluded by Edward C. Harding, who spoke on "The Importance of Intergovernmental Relations in Public Works." He is a member of the Board of Directors, Sanitation Dist. No. 1 of Campbell and Kenton Counties, Ky.

The separate water works session on Tuesday morning was opened by a paper on "Meter Maintenance and Repairing" by Jerome W. Baker, of the Memphis water meter shop. "The Membrane Filter Technique and Its Application to Water Analysis" came in for its share of discussion in a paper presented by E. L. Shipe, assistant director, Div. of Labs., Tennessee Dept. of Public Health. The mechanics of "Valve Insertion" were thoroughly presented by representatives of two companies: Ray DeWeese, of the Mueller Co., and G. J. Manahan, general sales manager, A. P. Smith Mfg. Co.

A very interesting paper on the "History and Expansion of the Nashville Water System" was presented by Robert L. Lawrence Jr., director and chief engineer of the Nashville Water Dept., who disclosed that a part of the first bond issue for the original system was used to purchase slaves, who were used for labor on the construction project.

The afternoon session heard a paper on "Wells—Their Maintenance and Rehabilitation" by T. M. Ragsdale, vice-president, Layne-Central Co., Memphis, and spent the remaining two hours in a Water Works Operator's Forum moderated by E. E. Jacobson, manager, Lexington Water Co. The most popular topic appeared to be the policy that should govern major main extensions, particularly in new subdivisions.

The closing joint session on Wednesday morning heard Morton I. Goldman read a paper on "Radioactivity Fallout in the Cincinnati Area" by J. S. Nader, A. S. Goldin, and L. R. Setter, of the Robert A. Taft Sanitary Engineering Center, Cincinnati (*see* this issue, p. 1096). "Blanket Liability Insurance" was the subject of a discussion by W. Louis Simpkins, manager, Service Dept., Kimbrough & Phillips Co., Nashville. The technical session was closed with a paper by Sam Richardson on the "Manufacture of Newsprint in a Modern Mill." Richardson is in the Technical Service Dept. of Bowaters Southern Paper Corp., Calhoun, Tenn., and described the new mill recently constructed there.

On Monday night the meeting was treated to a special show of the Grand Ole Opry, provided by stars of Radio Station WSM's show of the same name. "Opry," Tennessee style, was appreciated by all, as evidenced by the reluctance to call it quits when the show was over. The annual banquet and dance featured no speeches, which is a popular custom of this section. The following officers for the coming year were introduced: Chairman: J. Stephen Watkins, Lexington; Vice Chairman: Justin J. Davis, Memphis; Director: Charles H. Bagwell, Knoxville; Secretary-Treasurer: J. Wiley Finney Jr., Lexington; Trustee (Tenn.): Joe W. Lovell, Murfreesboro; Trustee

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Section Meetings

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(Ky.): Robert A. Fischer, Covington; and Past-Chairman: R. P. Farrell, Nashville.

Ladies' entertainment included luncheons, a hat show and trips to the Hermitage, home of Andrew Jackson.

J. WILEY FINNEY JR.
Secretary-Treasurer

Michigan Section: Muskegon, Mich., a thriving industrial city, was host to the sixteenth annual meeting of the Michigan Section on Sep. 15–17, 1954. A warm welcome was extended by all communities in the area.

A record attendance of 339, 76 of whom were ladies, attested to a well-planned program. Chairman Douglas Feben, called the meeting to order and we were duly welcomed by Mayor John E. Medendorp. John E. Vogt of the State Dept. of Health gave his usual good coverage of the year's developments in a paper entitled "News from the Field." He stressed especially the problems related to the unprecedented expansion of urban areas.

Descriptions of the water filtration plants in Muskegon and Muskegon Heights were presented by R. Lee Sensabaugh and Louis Haase, respectively. Both plants were open for inspection during and after the conference.

On Wednesday afternoon, A. C. Michael and G. I. Stormont of the Detroit Dept. of Water Supply presented a joint paper on "Choosing the Proper Motor and Controls for High-Lift Pumping." Mrs. Florence Booth, attorney, and Norman Billings coauthored a paper on "Legal Implications of Ownership and Control of Ground and Surface Water."

Thursday morning was devoted to a concentrated treatment of "Problems of

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Section Meetings

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Distribution Systems and Their Solution." R. C. Loughead of the Michigan Inspection Bureau explained the value of hydrant flow tests and Alfred E. Hansen, consulting engineer discussed the use of distribution system pressure records. Cyrus Bird of the Pitometer Associates showed the value of leak detection and distribution system studies. A. T. Kunze explained the precautions and factors to consider in the design of booster stations. All four papers pointed out that distribution systems must be carefully designed, and not just permitted to grow.

At the afternoon session, George Schmid explained the steps in the formation of a Metropolitan Water Authority which serves several growing communities. Louis E. Ayres, consulting engineer, talked on "Water Charges to Areas Outside Corporation Limits," applying the new AWWA Water Rates Manual. This paper was followed by applications to the cities of Adrian and Ann Arbor by Carl Nelson and H. H. Caswell, respectively. H. Winston Hathaway, attorney of our host city, cited the legal liability of water superintendents and municipal officials.

At the closing morning session, Lawrence Beebe demonstrated the use of the new membrane filter. Claud Erickson of Lansing presented very interesting statistics compiled from information obtained from water supplies in Michigan.

A discussion introduced by Virgil Langworthy of the Chlorine Institute on "Safety Precautions in Handling of Chlorine and Chlorine Dioxide" was followed by explanations of actual installations by Joseph O'Dell, Lansing; Leo V. Garrity, Detroit; and Robert Haw, Flint.

At both the Smoker and Banquet, the manufacturer's representatives in cooperation with the Water & Sewage Works Manufacturer's Assn. played hosts in sponsoring the usual successful clubroom.

At the annual banquet, the Edward Dunbar Rich Service Award was presented to 51 persons for 25 years of meritorious and faithful service in providing and maintaining a safe and adequate water supply. A life membership was awarded to our veteran member and former director, Earl E. Norman. Edward D. Barrett was nominated to receive the George Warren Fuller Memorial Award "in recognition of his leadership qualities as a member, officer and past-chairman of the Michigan Section, and culminating in his outstanding achievement as general chairman of the Annual Conference of the Association held at Grand Rapids, Mich., in 1953." Dale Maffitt, AWWA president, presented the greetings of the Association. "Joe Hanneford," alleged circus clown, explained "Life Under Canvas."

A very entertaining ladies' program was provided. Thursday featured a bus trip to Fremont and an inspection through Gerber's baby food plant.

T. L. Vander Velde
Secretary-Treasurer

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Sleeves; see Clamps

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Ross Valve Mfg. Co., Inc.

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Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
DeZurik Shower Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
DeZurik Shower Co.
Foster Eng. Co.
Mueller Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Gulf States Asphalt Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr Co.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

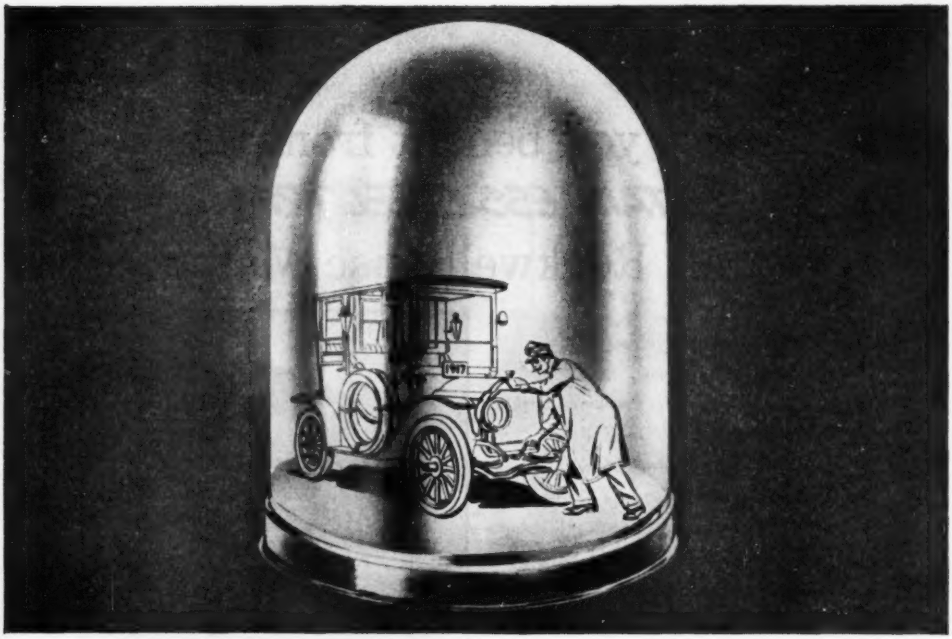
Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.



how much does it cost . . . to "crank" an old style chlorinator?

The automobile self-type starter isn't news any more — nobody ever cranks a car these days. "Cranking" an old-style chlorinator is equally out-dated.

The F&P mechanical, instrument-type chlorinator is sweeping the country, sales mount month by month. Why? Because municipality after municipality, consulting engineer after consulting engineer, reports the same facts: F&P chlorinators are lower in first cost, are easier to handle, because they are so simple in design, so light in weight, so modern in construction. More important, however, it is always stressed that F&P chlorinators require practically no maintenance, practically no spare parts.

We claim that if you are operating a chlorinator that has a bell jar on it *you need a new chlorinator.* You are "cranking" an old, costly, inefficient chlorinator. Everybody knows that dry chlorine is not corrosive—but that as soon as you put the chlorine in contact with water or water vapor it becomes corrosive. That's what the water tray types of chlorinators do—put dry, non-corrosive chlorine in contact with water and make corrosive vapor out of it. It's not engineering sense and the way to avoid it—and the resulting expensive maintenance — is to get F&P *mechanical, instrument type* chlorinators.

Don't refrain from writing us because you don't need additional chlorinating capacity right now. Moreover—if it is time for a major overhaul or a rebuilding of your bell jar chlorinator, let us quote you for doing this work. We will give you what you may not have gotten previously—a firm price for doing the job before we start on it. The price will be a reasonable one, but we'll also quote you a price for replacing the chlorinator and if you want to spread the cost of the new one by time payments or if you want a lease arrangement, you can have it. Chances are you cannot justify further overhaul or further rebuilding—even at our *fair* price for doing the work.

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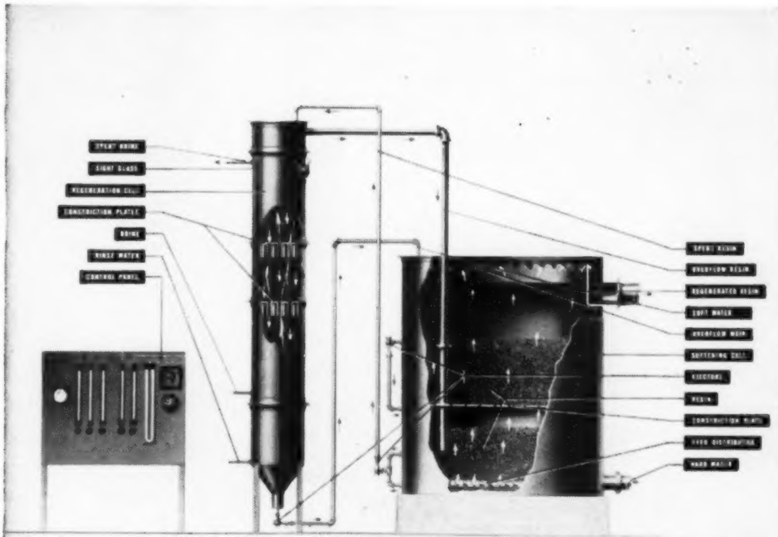
FISCHER & PORTER CO.

1014 Fischer Road, Hatboro, Penna.

18 YEARS EXPERIENCE SUCCESSFULLY MANUFACTURING CHLORINE FLOW METERING EQUIPMENT



Illustrative drawing of the Dorrco Hydro-Softener. Note that regeneration is carried out in a separate tank from the softening cell to minimize danger of contaminating treated water.

New! Base Exchange Softening Goes Continuous...

They said it couldn't be done. But at Baxter Springs, Kansas, a Dorrco Hydro-Softener has been in successful operation since October 1952. Both the softening cycle and the regeneration cycle are 100% continuous . . . no shutting down to regenerate and rinse, no periodic slug discharge of high salt content brine to contaminate the sewer . . . but a continuous supply of soft water at a constant quality going into the mains. What's more, installed cost of the Hydro-Softener is lower than with a conventional cation exchange softener and more efficient regeneration and lower rinse water requirements add up to lower operation costs.

If you'd like more information on this new development in water treatment practice, drop a line to The Dorr Company, Stamford, Conn. Bulletin No. 4083, just off the press, describes the Dorrco Hydro-Softener in detail. A copy is yours for the asking.

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Jointed for . . .
Permanence
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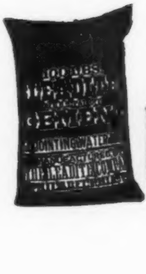
Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%



THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking